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JOHN TYNDALL, LL.D., F.R.S.

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DISTINGUISHED in his generation for devotion to original research, this eminent man of science has indirectly contributed to practical knowledge much more than many whose sole occupation and thoughts have been practical. The beginning of life had, indeed, for him the aspect of labour rather than of contemplation and investigation, but that beginning instilled accuracy as well as endurance. As one of the subordinates in the Ordnance Survey of the United Kingdom he acquired a taste for exercise in the open air that has never left him. Reducing the uneven places of his own county to a map led him over hills and through valleys more than among towns, and laid the foundation for the remarkable enterprises of the Alpine Club—an institution that may fairly be ascribed to his indefatigable zeal, and his unswerving love of nature.

Leighlin Bridge, near Carlow, is the birth-place of Mr. Tyndall. His family were of the lowliest, for the fortunes of the race appeared to have been declining from their immigration in the 17th century when they left England. His father had the reputation of personal courage, intellectual power, and delicacy of mind and feeling, which qualities are indubitably inherited by his son. Leighlin Bridge may be said to be an English colony. There stood Black Castle, which in the days of old had to endure many a brunt at the hands of the native Irish. It was one of England's earliest defences in that county. A large monastery was founded in the time of Henry III., and the ecclesiastics built the bridge to connect the religious houses on both sides the little river. Associations of this character, combined with home influence, induced in young Tyndall a relish for religious controversy which has not as yet died out of him: only that in those days the champions of Protestantism were his favourite authors, and in these days he draws his inspiration from deeper springs, untasted by many of those whose official position should lead them to a more courageous and truthful study of the deep things of God.

The village school provided the young natural philosopher with the elements of knowledge, and it happened, as in those days was not uncommon, that the humble schoolmaster possessed considerable mathematical knowledge, and strove to discover a juvenile mind that could share in his pleasures. From him Tyndall acquired a love of pure geometry which qualified him to accept an offer of work from the staff of the Ordnance Survey when they visited Carlow to map the county. He entered on his duties with all the ardour of one who longed to be of use, and had found a congenial occupation. Colonel Wynne, his chief, saw the inquiring youth, and discerning the bent of his mind afforded him all the facilities, and exercised all the patience he had in his power. Thus encouraged, Tyndall laboured at all the details of his new profession, and became first a draughtsman, then a computer, surveyer, and a trigonometrical observer. These avocations qualified him, as has been above stated, for his future investigations in the Alpine region.

Modes of life have greatly changed since that time. Humble as his lot must have been, he, like a great many others, continued at school until more than eighteen years of age, when of course his constitution was settling, and his habits of life had also become confirmed. Thoughtful and active, body and mind were qualifying for the tough work of his subsequent career. It is not to be wondered at that when once he became busy there dawned on him a desire to see the world and push his fortune. He continued for five years surveying and studying, for he gave his leisure of five hours a day to systematic study, soon after he began his engagement, rising at five in all weathers. This, he says, was at the recommendation of a kind friend who discerned in him capacity and love of knowledge. He appears to have been sated with surveying, and seeing no definite prospect before him he determined to follow a part of his father's family who had emigrated to America some years before: but just as that resolve assumed active form he was induced by the Dean of Leighlin—a good natural philosopher—to stay at home and accept an engagement on the railway surveys, which at that time, 1844, were at the very height of excitement. He accepted an engagement with a Manchester firm, and for a year had agreeable occupation in engineering labours in the valleys of the Cheernet and the Dove as well as on the Great Ouse in Bedfordshire. These were toils; the "Mania" at its height, surveyors could not go fast enough. His natural caution and accuracy, his perseverance, marked all his work, and many are the tales of his indomitable determination to have every bit of the result perfect at whatever expenditure of toil.

When the railway fever subsided Tyndall could see no worthy future in that department of industry, and accepted the post of tutor in Queenswood College in Hampshire, just after that institution had commenced work. That college differed from all others in its aims and methods. While a school, it was devoted chiefly to the technical education of agriculturists and engineers. Around it there lay 800 acres of land, upon which, besides farming, surveying, levelling, and other engineering operations were to be practically taught. In the college staff was a resident chemist whose laboratory Tyndall hoped to be able to utilize. He studied as well as he could, but both himself and the chemist—afterwards Professor Frankland of the Royal Institution—sought a wider field, and they went in 1848 to the University of Marburg in Hesse Cassel, where Professor Bunsen was the teacher. The rich stores of that tutor's mind and his laboratory were freely opened to the young student; indeed he became, like his master, a natural philosopher of the first order. What that teacher was to Tyndall may be gathered from the fact that twelve years after he dedicated his celebrated book on "Heat a Mode of Motion," to "his friend and teacher Robert Bunsen."

The life at Marburg contributed to Tyndall's progress in a remarkable manner. In fact, he may be said to have made his present position upon that foundation. Knoblauch the lecturer became his friend, and joined him in a paper to the Philosophical Magazine in 1860, and he had the advantage of Hegmann's mathematical lectures. This brought him to the front. People at home wanted to know who was this Englishman of thirty years of age proclaiming new ideas on such abstruse topics as the magneto-optic properties of crystals, &c., and defending his statements with investigations of a practical kind. A young man must have had courage to append to his paper: "If these views be correct the optical axis can no longer be regarded as the prime agent in the production of the phenomena we have been considering: *we shall no longer seek the explanation of facts in the hypotheses of new forces, but rather in modification of the old.*" This marks the career of Tyndall: twenty-eight years have borne witness to the fidelity with which he has maintained a stern repudiation of the encrusting fallacies that have concealed truth, and his loyalty to the conviction that by modification of old theories, we must look for the explanation of facts.

In the following year he went to Berlin and continued his studies on the same subject in the laboratory of Professor Magnus, whose apparatus had the highest repute for perfectness, and whose hospitality created for the Englishman a home in a foreign land. Friends multiplied. He grew in knowledge, and in favour. The subject he had selected happened to be a new one, and the field remained his own freehold; he made fame by every disclosure of his thoughts, and the results of his investigations. Berlin had long been the home of continental philosophers, and thither did the travelling Englishman who loved science or metaphysics bend his steps. So that when he went back to London in 1851, he obtained a prompt introduction to Professor Faraday, and received an invitation from that learned man's friend, Dr. Bence Jones; also General Sabine, who had been struck by the originality of his investigations, wrote to him and offered his influence toward his election as Fellow of the Royal Society. This was done in 1852, and Tyndall gave his first lecture to that learned body in 1853. His career now became one of triumph. Style, knowledge, originality, power of communication combined to make him at once a successful man, which position he has maintained during the subsequent five and twenty years, with unabated lustre and undimmed honour. The Royal gave him the Professorship of Natural Philosophy in June of that year, conjoined with the office of Superintendent, which had been held by Faraday up to that date.

Devoting himself to these studies for the most part, he found time to publish an essay on the clearage of slate rocks; and this brought him into a lasting friendship with Mr. Huxley of the Geological Society. The two resolved on a visit to Switzerland in 1856, for the purpose of scientific investigations on that subject in connection with that of glacier-ice: on their return a joint publication of their journey appeared, On the Structure and Motion of Glaciers.

These visits to the Alps followed yearly, and the facts he gained unfolded a world of discovery, that had been absolutely sealed up until he came. Those of our readers who desire to follow this intrepid searcher after knowledge, will find romantic adventure, and a mass of information, in his Glaciers of the Alps, the like of which is not to be found once in half a century. Invigorating and instructive no doubt such adventures are, and as Mr. Llewellyn Davies observed of his climbing the Dome, it invigorates heart and mind, besides the benefit of the body; but

there cannot be a question that the traveller must have first a heart to love the work, a mind to appreciate and assimilate knowledge, and a body incapable of fainting. Tyndall, taking a night on the top of the Alps just to see what conditions prevailed, and what the sunrise ventured to disclose, is a sample of endurance, that few of this self-indulgent age would ever try to emulate, and we do not know who would aim to excel. Engineers have tremendous demands upon their physical powers, but up to one's lips in snow for half a dozen hours in order to acquire an idea, is what most of us would look at twice before acceptance, especially when the sum total was three days on the mountain and *so* cold.

We do not wonder that after this he should have commenced in 1859 his marvellous investigation concerning "Radiant Heat." It was a fit after-piece to his lucid exposition of the origin and phenomena of glaciers, and the physical properties of ice. From these we date the end of laborious athletic labour, and now will try to note what service such work has been to the bulk of mankind and the development of truth, whether in nature, culture, morals, or science.

His appointment at the Royal Society occurred at a time of intense interest to the scientific world; indeed, fortune, it must be confessed, has made time and circumstance conducive to the advancement of one of the worthiest of our race, for the Great Exhibition had not lost the radiance of its glory. The inspiration which science had infused had not faded from memory when Tyndall delivered at the Royal Institution a lecture "on the importance of the study of Physics, as a means of Education for all Classes," a title which he said conveyed exactly the idea that guided him in its delivery.

In treating of the life of John Tyndall we are quite aware that the result must be found in the lessons he has taught, and the discoveries he has made. We cannot point to Saltoun or Barrow-in-Furness or even to huge factories, and say, this is his handiwork, but we will try and find out the key of a life that by its principles can bless every man, especially practical scientific men, in their daily avocation and their incessant hopes and endeavours. That will be to do honour and give reward to one who is still among us, and to help forward instantly those whose young lives are often weakened or depleted by frivolity or listlessness.

Let us take the lecture above-named. "The study of Physics a means of Education." "Physics is an implement of culture, for the general expansion of the intellectual powers implies both the acquisition of specific knowledge and the ability to render it productive. No age can lay down a system of education which shall hold good for all ages. The basis of human nature may be permanent, but not the forms of its manifestation. . . . . You cannot with reason demand unconditional acceptance of past systems or divorce men from the times in which they live. . . . . While thankfully accepting what antiquity has to offer, we must not forget that the present century has just as good a right to its own forms of thought and methods of culture as any former centuries had to theirs, and that the same sources of power are open to us to-day, as were ever open to man in any age of the world." Again, in that same lecture, he pleads for scientific education in preference to that of philology. "Is there no mind in England large enough to see the value of both? Let the gleaned wealth of antiquity be showered into the open breast; but while we unsphere the spirit of Plato, and listen with delight to the lordly music of the past, let us honour, by adequate recognition, the genius of our own time. Let me again remind you that the claims of that science which finds in me to-day its unripened advocate, are the claims of God's workmanship upon the attention of His creatures, and that its exercises, as an agent of culture, are based upon the natural relations subsisting between man and the world in which he dwells. Here, on the one side we have the apparently lawless shifting of phenomena; on the other side, mind, which requires law for its equilibrium, and in obedience to its own indestructible instincts believes that these phenomena are reducible to law. To chasten this apparent chaos is a problem which man's Creator has placed before him. The world was built in order; it is the visual record of the Creator's logic, and to us He has entrusted the will and power to follow Him through this great argument. By the manifestations of nature which He has ordained, He appeals to the faculties which He has implanted, and surrounds them from the cradle to the grave with objects which provoke them to inquiry. Descending for a moment from this high plea to considerations which lie closer to us as a nation—as a land of gas and furnaces, of steam and electricity; as a land which science, practically applied, has made great in peace and might in war:—I ask you whether this 'land of old and just renown' which may God keep unimpaired, has not a right to expect from her institutions a culture more in accordance with her present needs than that supplied by declension and conjugation? And if the tendency should be to lower the estimate of science, by regarding it exclusively as the instrument of material prosperity, let it be their high mission to furnish the proper counterprise by pointing out its nobler uses and lifting the national mind to the contemplation of it as the last development of that 'increasing purpose' which runs through the ages and widens the thoughts of men."

This admirable lecture is one of the finest of Tyndall's many publications, and no one could be surprised that in the following year 1855 he received from the University of Cambridge the degree of LL.D., which was followed, some ten years after, by that of the University of Edinburgh.

Profound as have been many of the contributions to Scientific knowledge made by Mr Tyndall, we incline to think his most fruitful work has been in the simplification of abstruse technicalities, and disclosing even to children stores hitherto hidden through scientific terms from the common understanding.

Four volumes may be specially referred to, as characteristic of the methods he adopts in conveying knowledge. They are "Heat, a Mode of Motion," "Fragments of Science," "Experimental Physics; "On Light." There are several smaller works, containing lectures delivered at the Royal Society on Scientific Subjects, and these are distinguished for the simplicity of their style, and the cleverness of their information. The first of these is perhaps the most remarkable. It has gone through five editions, and is as popular at the present time, as when it was first issued in 1863. Since then large editions of it have been issued in France, Russia, and America, and a translation in German. He had held the position of Examiner for the University of London, and the Council of Military Education, and Lecturer at the School of Mines, and found cause to deprecate and deplore the utter want of scientific knowledge, and the utter absence of sympathy with scientific studies, which mark the great bulk of our otherwise cultivated English public. He aimed to supply the deficiencies indicated. The work on "Heat," was the first fruit. The second was on "Sound;" the third on "Light." He says, "I have endeavoured to bring the rudiments of a new philosophy within the reach of a person of ordinary intelligence and culture. Seven lectures deal with thermometric heat; fire of radiant heat; and the aim was, "to rise to the level of these questions from a basis so elementary, that a person possessing any imaginative faculty and power of concentration, might accompany the writer in his discourse."

His own description is at once the best and clearest. "I have called the philosophy of heat a 'new philosophy,' without, however, restricting the term to the subject of heat. The fact is, it cannot be so restricted; for the connection of this agent with the general energies of the universe is such, that if we master it perfectly, we master all. Even now we can discern, though but darkly, the greatness of the issues which connect themselves with the progress we have made—issues which were probably beyond the contemplation of those by whose industry and genius the foundations of our present knowledge were laid."

"In the study of nature two elements come into play, which belong respectively to the world of sense and to the world of thought. We observe a fact and seek to refer it to its laws,—we apprehend the law, and seek to make it good in fact. The one is theory, the other experiment; which, when applied to the ordinary purposes of life, becomes practical science. Nothing could illustrate more forcibly the wholesome interaction of these two elements than the history of our present subject. If the steam-engine had not been invented, we should assuredly stand below the theoretic level which we now occupy. The achievements of Heat, through the steam-engine, have forced, with augmented emphasis, the question upon thinking minds,—'What is this agent, by means of which we can supersede the force of winds and rivers—of horses and men? Heat can produce mechanical force, and mechanical force can produce heat; some common quality must, therefore, unite this agent and the ordinary forms of mechanical power.' This relationship established, the generalising intellect could pass at once to the other energies of the universe, and it now perceives the principle which unites them all. Thus the triumphs of practical skill have promoted the development of philosophy. Thus, by the interaction of thought and fact, of truth conceived and truth executed, we have made our science what it is,—the noblest growth of modern times, though as yet, but partially appealed to as a source of individual and national might."

Again,—"The discoveries and generalizations of modern science constitute a poem more sublime than has ever yet addressed the human imagination. The natural philosopher of to-day may dwell amid conceptions, which beggar those of Milton. Look at the integrated energies of our world,—the stored power of our coal fields; our winds and rains; our

fleets, armies, and guns. What are they? They are all generated by a portion of the sun's energy which does not amount to $\frac{1}{236,000,000}$ of the whole. This is the entire fraction of the sun's force intercepted by the earth, and we convert but a small fraction of this fraction into mechanical energy. Multiplying all our powers by millions of millions, we do not reach the sun's expenditure. And still, notwithstanding this enormous drain, in the lapse of human history we are unable to detect a diminution of his store. Measured by our largest terrestrial standards, such a reservoir of power is infinite; but it is our privilege to rise above these standards, and to regard the sun himself as a speck in infinite extension—a mere drop in the universal sea. The energy of nature is a constant quantity, and the utmost man can do in the pursuit of physical truth, or in the applications of physical knowledge, is to shift the constituents of the never-varying total, sacrificing one if he would produce another. The law of conservation rigidly excludes both creation and annihilation. Waves may change to ripples, and ripples to waves . . . . the flux of power is eternally the same. It rolls in music through the ages, while the manifestations of physical life, as well as the display of physical phenomena, are but the modulations of its rhythm."

We will now notice his book on Sound. There are few of the physical sciences which have so interesting a history as acoustics. The scattered notes of students are brought together by Dr. Tyndall and exhibited as a whole. Galileo, Taylor, Newton, Le Grange, Sauveur, and others, contributed to what is now presented in a more orderly and scientific form than has heretofore been possible. Just now the subject has acquired a fresh impulse from the development of the telephone, which Wheatstone, Willis, and Helmholtz saw was coming, and so did another, Sir David Brewster, who said, "I have no doubt that before another century is completed a talking and a singing machine will be numbered among the conquests of science."

We need not describe the organism of the human voice by which sound is produced, or the physiological operations that are produced by the will.

If the analysis of alphabetic sounds be complete, we foresee the conditions of all artificial semblances. Let the reader press on the right pedal of a piano so as to free all the strings from their dampers. Let him then expose the strings and sing any one of the vowels on a particular note with the instrument, directing his voice on the wires. When the voice ceases there is a clear full echo of the note and of the vowel sound selected. The effect is very remarkable at night. Every tone and overtone of the original sound awakens the shaking sympathetic strings, so that they give back the compound sound out of the same simple elements into which it spontaneously analysed itself.

Dr. Tyndall then describes the mechanism of the ear as he had that of the voice, and we cannot doubt that, like Faraday and Wheatstone, he has been the real guide and philosopher of those who in the puffing telephony of to-day are making a kind of reputation for discovery in which they have done little or nothing. Even Tyndall confesses his great obligations to Helmholtz, but our moderns ignore all their predecessors.

A charming series of six lectures on Light, delivered in America in 1872-3, embody and include many previous speculations by the author on that subject, and have placed him in the first rank of another department of Natural Science. His conception of his duty is well put in this paragraph: "Experiments have two great uses—a use in discovery and verification, and a use in tuition. They were long ago defined as the investigator's language addressed to Nature, and to which she sends intelligible replies. These replies, however, usually reach the questioner in whispers too feeble for the public ear. But after the discoverer comes the teacher, whose function it is so to exalt and modify the experiments of his predecessor as to render them fit for public presentation. This secondary function I shall endeavour, in the present instance, to fulfil. I propose to take a single department, and illustrate, by means of it, the growth of scientific knowledge under the guidance of experiment."

And so he enters on the Science of Optics, and produced a volume that completely eclipses the great works of Brewster and Gardner, and is a fit supplement and an inclusive tutor of the knowledge gained by Professor Airey's experiments.

His instruction on Light is intimately connected with that on Heat, thereby illustrating his repeated doctrine of the inherent connection of every department of nature, and the universal applicability of its laws. The generation of light and heat by electricity, and its communication to distant places, is graphically summed up. By this arrangement, we are able to burn our zinc at one place, and exhibit the effects of its combustion at a distant place. In New York, for example, we may have our grate and fuel; but the heat and light of our fire may be made to appear at San Francisco.

But how refreshing it is to notice the candour of Tyndall, when reviewing the labours of the ages, the honour he gives to Newton, Boyle, Young, whose vindictive assailant was Brougham, Hooke, Wheatstone, Bunsen, Kirchoff, and the whole army of honest searchers after truth. The book abounds in delightful illustrations of the most simple kind, but which confirm the most recent and profound discoveries of science. Just a few extracts on his conception of the right place we should hold in reference to science will end this part of our remarks.

"This is the core of the whole matter as regards science. It must be cultivated for its own sake, for the pure love of truth, rather than for the applause or profit it brings. In reference to the men who have bequeathed to us the vast body of knowledge, what motive spurred them on? They did not propose to themselves money as an end, and knowledge as a means of attaining it. For the most part they reversed the process, they made knowledge their end, and what money they possessed gave the means of obtaining it. . . .

"Could we have seen those men at work, not consequences of their work, what should we have thought? They might often appear as big children playing with soap-bubbles and other trifles. If you were to ask such a one, what is the *use* of his work, the chances are that you would confound him. He might not be able to tell you the use of it in intelligible terms. He might not be able to tell you that it will put anything into the pocket of any human being living or to come. Scientific discovery *may* put money into the pockets of individuals, and millions into the exchequers of nations; this the history of science amply proves; but the hope of its doing so never was and never can be the motive power of the investigator.

"People sometimes speak as if steam had not been studied before James Watt, or electricity before Wheatstone and Morse, whereas those men, with all their practicality, were the mere outcome of antecedent forces that acted without reference to practical ends. You are delighted, and with good reason, with your electric telegraph, proud of your steam engines and factories, and charmed with the productions of photography. You see daily the creation of forms of industry that add wealth and comfort to society. Yet what are industrial America and industrial England? I will answer. Strip a strong arm, and look at the knotted muscles when bent. Is that energy the work of the muscle alone? No. The muscle is the channel of an influence without which it would be powerless as plastic dough. The nerve unlocks the power, and without the filaments of genius shot like nerves through the body of society by the original discoverer, industrial England and America would be very like plastic dough.

"There is a great cry for technical education,—a cry in which the most common-place intellect can join, its necessity is so obvious. But there is no cry for original investigation! without this, as surely as the stream dwindles when the spring dies, will 'technical Education,' lose all force of growth and power of reproduction. Our great investigators have given us sufficient work for a time, but if their spirit die out we shall find ourselves in the condition of those Chinese mentioned by Tocqueville, who, having forgotten the scientific origin of what they did, were at length compelled to copy without variation the inventions of an ancestry who, wiser than themselves, had drawn their inspiration direct from nature.

"England and America have reason to bear these things in mind: the largeness and nearness of material results are too likely to cause both to forget the small spiritual beginnings in the mind of the scientific discoverer. You multiply, but he creates. If you starve him, or otherwise kill him, nay, if you fail to secure him free scope and encouragement, you not only lose the motive power of intellectual progress, but infallibly sever yourselves from the springs of industrial life.

"What has been said of technical operations, holds equally good of education. The investigator is the fountain-head of knowledge. It may be doubted whether the real life of science can be fully felt and communicated by one who has not been taught by direct communion with nature. We may have good and instructive lectures from men of ability, the whole of whose knowledge is second-hand, just as we may have good instructive sermons from intellectually able and unregenerate men. But for that power of science, which corresponds to what the Puritan fathers would call experimental religion in the heart, you must ascend to the original investigator."

His books on *Heat*, *Sound*, and *Light*, are the true examples of his teaching, and are a mine of wealth to every lover of Natural Research.

Among the recent works is his Fragments of Science, a collection of papers written for the purpose of extending sympathy for science beyond the limits of the scientific public. We can only give their titles. The Constitution of Nature—Radiation—Radiant Heat in relation to Colour and Chemical Constitution

of Bodies—Reactions produced by Light—Dust and Disease—Voyage to Algeria to observe the Eclipse—Niagara—Faraday's Life and Letters—Copley Medalists—Elementary Magnetism—Death by Lightning—Science and the "Spirits." The essays in the second part startled a good many at the time and since, but their power is being felt now that lame prejudice has nearly died out concerning them. The celebrated address to the British Association at Belfast seemed to be an attack on orthodoxy, and an elevation of science in defiance of religion, merely because of the gross ignorance of the clergy concerning the world in which they live, and their infidelity to the truth wherever found. Tyndall is well known to be a man of deepest piety. The depth of his piety is like the light of his discoveries—not to be appreciated by those who know nothing of one or the other; and that, it grieves one to say, is awfully true of the pulpit guides who denounce that of which they know nothing, in places where no reply can be given. "Here and there was heard," said he in his Belfast address, "the voice of one impatiently crying in the wilderness, 'Not unto Aristotle, not unto subtle hypothesis, not unto Church, Bible, or blind tradition, must we turn for a knowledge of the universe, but to the direct investigation of nature by observation and experiment.'"

This investigation has exploded what all honest theologians who had scholarship have been ever free of—the doctrine of plenary inspiration, and the duty of worshipping the words without reference to the spirit. Science is always struggling after the unknown, but it makes sure work of what it does know: and it knows that the Book of Genesis is not history, and it loves the Father of our Lord Jesus Christ all the better for that conviction. "The impregnable position of science may be described in few words. We claim, and we shall wrest from theology, the entire domain of cosmological theory. All systems and schemes which thus infringe upon the domain of science, must, *in so far as they do this*, submit to its control, and relinquish all thought of controlling it. Acting otherwise proved disastrous in the past, and it is simply fatuous to-day." These words are not spoken a moment too soon. The fate of Galileo, Copernicus, and a dozen or twenty other children in the school of natural science, ought to be a caution to the arrogant in modern times. They may as well attempt to smooth Mont Blanc with a rolling pin, as interfere or dispute with the scientific faculty that, having no antagonism to creeds, declines to pretend at seeing what it knows to be untrue.

We have left but little space to notice the work of Dr. Tyndall in connection with the Swiss scenery, and with that our notice must end.

Every lover of nature loves mountains; the air is grateful, the prospect enchanting, the climbing exhilarating, and the memory everlasting. Tyndall went to Switzerland as all who are children of nature, simply because he could not help it, and the inspiration that led him there did not leave him to find his own way; it guided his way, his thought, his reflections, and his conclusions. The narrative is a perpetual delight to all future generations. Looking at a mountain he would know, how came it of that shape? what is it made of? how long a time was occupied in its formation? of what use now it is there? and what does it teach? Did anybody ever live on it? how came it to be so high? And last what makes men love to endure fatigue and laborious thought in exploring and investigating such enormous physical objects?

These and a hundred other questions occur instantly that the Alps are thought of, and to add to them there is the eternal snow, making the peaks ghost-like in the dusk, and glistening with a thousand colours in the sunshine; and the lover of nature wants to know all about that; and then the glacier attracts his attention, and offers him the opportunity to speculate. Ice-cataracts, ice-fields, frozen seas, and a marvellous conglomeration of sand rubbish and forestal deposit intermingled, fill him with delight that is of the highest form our existence can possess of rapture. Tyndall has no sooner arrived in the society of glaciers than a hidden power burst forth; he became instantly a first-class mountaineer, and his achievements eclipsed all previous Alpine explorers. "Peaks, Passes, and Glaciers" is a book of undying interest, not that the wonders of the region were unknown, but that they had never before been explored by such a bright-eyed enthusiast, who to the love of adventure was endued with spiritual intelligence. Theories had abounded, but being based on wonder and a love of the marvellous, they failed to excite attention. Tyndall saw the wonder and delighted in the marvellous, but emotion became but a servant in his course of scientific inquiry. We cannot here retrace the old ground, or indeed describe the new. Schenchzer and Gruner, Saussure and Charpentier were all followed by Professor Forbes in connection with Agassiz: but all found their best exponent and adjuster in Tyndall, who, notwithstanding the sharp controversy that ensued, is now accounted the worthy chief as he ever is the unassuming traveller. The anger or jealousy or antagonism that Forbes exhibited is gone and left no trace, and from this cause. Tyndall is remarkable for boldly exhibiting the courage of his opinions not from a self-love but from a truth-love; expecting to be denied and not surprised at being disparaged, he, taking his stand on perceived truth, calmly waits until the storm has wearied itself to rest, and leaves his work the only relic that can endure.

Enough has been said to commend the study of Tyndall to all practical men, for they above all classes of mankind are most in need of the guidance of a true investigator, who loves knowledge for its own sake, and for the insight it gives into the nature of God, and the nature of man—a knowledge infinitely more valuable than riches or fame.

W. S. C.

COMPOUND OF NITROGEN.

AMMONIA AND AMMONIACAL SALTS.—NITRIC ACID AND ITS SALTS.

DR. H. HOFMAN occupies a position on the Continent in all matters affecting chemistry as applied to manufacture, as useful to the world as it is honourable to himself. Of great and varied experience and singular clearness of mind, he speaks with authority that commands respect as much from the value of his communications, as from the modesty with which they are put forth. And another singular phase of his nature is seen in the willing aid he can obtain from his fellow labourers who cheerfully supply information in their several departments, without the least jealousy or hesitation. In his current production "*Berichte über die Entwickeling der chemischen industrie wähoend des letzten ahgnzehends*," he furnishes two reports which we quote. The first on *Ammonia and Ammoniacal Salts* is by M. Seidel, Director of a manufactory in Amsterdam. The official reports of the International Exhibition held in London in 1862, asserted that the manufacture of ammonia remained in the same condition as in 1851, but during the past ten years there has been a material change, developing the industry both technically and commercially, to a very surprising extent. Until the year 1860, the manufacture of ammoniacal salts was trifling, as compared with the then existing supply of the raw material, and the price did not stimulate an increased production, besides which all the technical manipulations were of the most primitive and elementary character.

Agricultural Chemistry has made great progress of late, especially since the year 1870, and the use of sulphate of ammonia for agricultural purposes has increased year by year calling into existence new methods of production, and new and greatly extended markets in order to keep pace with that demand.

Sulphate of ammonia is now employed almost exclusively in agriculture or in the manufacture of alum. Caustic-ammonia has also obtained an increased demand for many purposes, while sal-ammonia, both sublimed and crystallized, have fallen off in consumption, so that in many establishments the machinery used for its production has been removed, to be replaced by apparatus adapted to the manufacture of the sulphate of ammonia.

There has been no noticeable change in the sources from whence ammonia is obtained. First and chief is the product of the gas works, the so-called ammoniacal liquor or gas water; in comparison, all other raw materials are hardly worthy of enumeration. The waste of prussiate-of-potash works from the manufacture of animal charcoal and from stall urine and the like, form a small fraction of the total, and will probably increase. Many proposals for obtaining ammonia have been made from time to time, some new, some old, some revivals. It is said that Mr. Hunt patented a process for obtaining sal-ammonia by passing a mixture of hydrochloric acid and nitrogen over burning coke that had been previously saturated with ferric or manganous chloride. Hunt used salts of manganese, but Wagner, a German, recommended the same process eighteen years before, with the difference that he prescribed a salt of magnesia; but the process has not been utilized commercially. Hutchinson's process may be put in the same category; it consists in distilling the nitrogenous residues of the starch manufacture in retorts, in connection with lime or caustic soda.*

* Hutchinson claimed for Improvements in Patents No. 1118, 1862, and No. 2330, 1862, and in fairness they may be stated as relating to the manufacture of ammonia and the prussiates of soda, and to the

Brief mention must also be made of the method of Coste and Paupin de Rosnay for utilizing the ammonia of canal water; in which the water is mixed with magnesia and a soluble phosphate, the precipitate of ammoniaco—phosphate of magnesia is then collected, dried, and burnt in lime retorts. The ammonia thus given off is conducted into an acid, whilst the residue is utilized as manure. In this case also the matter has not gone beyond the experimental stage.

Ammonia prepared from gas water is partly collected in the condensers and partly in the washing apparatus of gas works. It consists of a mixture of volatile and fixed salts of ammonia in irregular and uncertain proportions. Among the volatile are ammonium sulphide and carbonate and free ammonia: of the latter are principally the ammonium salts of sulpho-cyanogen and hypo-sulphurous acid, with traces of sulphate and chloride. The total percentage of ammoniacal compounds fluctuates greatly, but as it is to the advantage of gas-works to absorb the ammonia as much as possible, and all concentration augments values, it is generally delivered of greater strength now than formerly.

The approximate valuation of the ammoniacal liquor is effected by means of a hydrometer, but as the specific gravity thereof is specially affected by both the quality of the water originally used, and by the presence of foreign constituents, the hydrometric valuation is very uncertain. The per-centage of fixed ammonia is on the average 0·3, whether the hydrometer indicates a higher or a lower degree. The per-centage of sulphur ranges from 0·33 to 0·50.

The utilization of the liquor is generally effected by expelling the gas in a process of distillation in iron boilers heated by fire or steam, air being simultaneously forced in. Some English manufacturers (such as Baggs & Simpson, and others), make use of apparatus resembling the scrubbers at gas-works, into which the gas-water flows down while the steam at a high tension rises up from below—a process that is not approved where the factory cannot use lime, or if employing it does so under unfavourable conditions.

At the works of Messrs Van der Elst and Mathes, Amsterdam, the greater part of the ammoniacal liquors from Dutch gas-works, which is conveyed by water in large barges constructed for the purpose, are treated as follows:—

The liquor is distilled in iron stills, holding from 35 to 50 hectoliters each, and heated by steam, furnished by five 30-horse power steam boilers. These stills are on one level and are grouped in pairs, which, being connected by reciprocating cocks can be worked alternately. First, the volatile constituents are distilled off without the addition of lime, and then the quantity of milk-of-lime necessary to decompose the fixed salts, is driven in by steam pressure. The product is passed into a collecting vessel, and from thence through 5 in. valve-cocks into large receivers filled with sulphuric acid where the ammonia is entirely absorbed, the cocks being arranged so that the produce may be conducted into one or the other receiver as may be desired.

The residue of watery vapour which is greatly contaminated with sulphuretted hydrogen and carbonic acid is removed from the receivers by a special chimney fitted with an arrangement for burning the sulphuretted hydrogen. On its passage to the chimney the escaping vapour traverses a long series of pipes, and the temperature of the gas-liquor that is to be distilled rises to 50° or 60°. In addition to the economy of fuel, this arrangement yields a further advantage in that the gaseous mixture deposits a great part of its watery vapour, thereby greatly facilitating the combustion of the sulphuretted hydrogen. By this method Messrs. Van der Elst and Mathes turn out about 1200 tons of sulphate of ammonia yearly.

Wherever gas-liquor is treated in quantity great attention must be devoted to the pernicious emanations unavoidable in the course of the manufacture; for without such precautions the atmosphere of the district is poisoned, and the men employed in the works suffer from severe inflammation of the eyes. These precautions are chiefly effected by improvements in the burners used for the combustion of the noxious gas, and the construction of chimneys with increased draft; further information is given at considerable length in a treatise published by the *Compagnie Parisienne d' éclairage et de chauffage par le gaz*, which has three establishments producing about 3000 tons of sulphate of ammonia, and large quantities of caustic ammonia annually. That note is a trustworthy guide concerning the sanitary regulation of such establishments.

Another improvement of much importance is the adoption of safety valves; these are now generally attached to all stills and should be universally. Notwithstanding that under ordinary circumstances chemical works are conducted at a low pressure, ob structions are occasionally produced in the tubes by various causes, but which issue in disastrous explosions, such as that which took place in 1867 at the establishments of Van der Elst and Mathes in Amsterdam, and of Kunheim & Co. of Berlin. These calamities are certainly prevented by the application of safety valves.

The consumption of sulphate of ammonia in agriculture has become more and more extended. In comparison with guano and other putrid manures, ammonia and ammoniacal salts have the great advantage that there is no waste; all the ammonia is retained; and although the effect is more protracted than is the case with guano, it is unquestionably more permanent.

There is also a manifest increase in the demand for caustic ammonia in various directions. The introduction of Carré's ice-machine has largely augmented its application, although the machine is defective in many ways, and disappointing in its results in consequence. Much is required for the composition of tinctures, and very recently there has been large exportation to the island of Java, where it is now being used in the preparation of indigo. By the old process of obtaining the colour from the various species of *indigofera*, lime was added to the fermenting mass, and it is due to the enterprise of a Belgian chemist, J. Sayers, of Djocjocarta in Java, that the new process has been introduced. He substitutes ammonia for lime during the fermentation, and thereby obtains a purer colour.

Some thirty years ago, a method of producing soda by treating chloride of sodium with carbonate of ammonia was tried without attracting much notice. That has been recently resumed, and has given a considerable impulse to the manufacture of ammonia; and if the process should come into use on a large scale, this will very essentially contribute to a further development of the manufacture of ammonia.

The fact that ammonia is capable of being much condensed, and that it is readily soluble in water, has awakened the idea of using it as a motive power for machinery. M. N. Tellier and Flandrim may be said to have been the early experimenters in this direction; and the former of these chemists has since endeavoured to make ammonia useful in many technological appliances. In this he has not been decidedly successful, because the commercial value of ammonia has increased most remarkably in the last few years. He published the result of his endeavours in a separate book,—*L'Ammoniaque dans l'Industrie*. Paris: J. Rothschild, 1867: and M. Delaporte patented an ammonia machine in France, in August 1865 (No. 63.)

The preparation of various ammoniacal compounds will be the last of the descriptions necessary for this part of the subject. Ammonia is fixed not only by acids, but by many salts, which in its case play the part of an acid. These compounds, which have been experimentally examined by H. Rose, Persoz, and Rammelsberg, give off the ammonia when heated; and this is a property often utilized in the laboratory for preparing liquid ammonia. Knabb, in *Deutsche Industrie Zeitung* 1866, proposed to obtain such saline compounds of ammonia in a commercial form, and to store up the gas in this form; by which such compounds would then only require a gentle heat to cause them to evolve a current of dry ammoniacal gas. Chloride of calcium can in this manner take up 50 per cent. of its weight of ammonia, whilst strong liquid ammonia contains only 20 per cent. of dry ammonia. Herein Knabb is wrong, for water even at 15° can take up more than 30 per cent. of dry ammoniacal gas. Peter Spence, of Newton, Lanc., obtained a patent, No. 2043, August 1866, for the production of sal-ammoniac in a commercial form by mixing chloride of ammonium or sulphate with twice the weight of lixivium—alkali waste of gas lime, exposing the mixture to the action of steam, and condensing the products of distillation by hydraulic or other presses with sufficient force to compress the particles into a solid cake. Kunheim has introduced a simple, but certainly advantageous improvement in the manufacture of carbonate ammonium. Hitherto it had been almost exclusively prepared by the double

apparatus. Refuse gluten and nitrogeneous matters of starch and other factories is submitted to destructive distillation in retorts along with lime or soda-and-lime condensing the ammonia evolved. The crude liquor can be purified by adding an acid and crystallizing by fittering or re-distilling. The prussiates of potash or soda are obtained by fusing the gluten, &c., in an iron pot with soda, the fused mass is then lixiviated with water, and the prussiates are crystallized from the solution, or the gaseous products of the destructive distillation of gluten or the like are fused over a mixture of charcoal and potash, or soda and iron, heated to redness: the charcoal is then lixiviated with water and saturated. Hutchinson used a retort in his manufacture fitted with a worm having a double action for feeding and discharging. In prussiates an iron pot or retort with pipes conveyed away the gaseous products evolved and hitherto wasted, and utilized them, by closing the pot or retort with a lid, to which is affixed an apparatus for feeding, consisting of a hopper or a worm, having a shaft that passes through the lid and turns upon an agitator in the roater or retort.

decomposition of sal-ammonia and carbonate of lime, the chloride of calcium which was relatively worthless, being obtained as a by-product. Instead of the carbonate of lime, Kunheim employs the carbonate of baryta, and obtains a solution of baric chloride, which may be advantageously used in the preparation of permanent white.

The second part referring to nitric acid and its salts, is contributed by Dr. Adolph Geyger of Berlin.

The consumption of nitrates in the chemical arts, and in the manufacture of gunpowder and other materials for blasting, had increased to such an extent as to exhaust all the earlier sources of supply, until a new district was opened up more than 50 years ago in the district of Tampa, on the borders of Chili and Peru, from whence it is still increasingly taken, and furnishes the largest part of the raw materials for the nitrates now used in the arts.

According to the statements of Dr. G. Langbein, there were in the year 1871, in the Peruvian nitre districts, eleven large refineries yielding daily 6000 cwts. of purified nitrate of soda. The nitriferous mineral, called *caliche*, is found in beds of from 0·25 to 1·5 metres in thickness, which, however, rarely rise to the surface. The superincumbent rock, *costra*, is from 1½ to 2 meters in thickness, and consists principally of a hard conglomerate of sand, feldspar, phosphates, and other minerals. The composition of the *caliche* fluctuates; it containes 48 to 75 per cent. nitrate of soda, 20 to 40 per cent. chloride of sodium, and varying quantities of sulphates of soda and lime, nitrate and iodate of potassa, chloride of magnesium, etc., and also insoluble earthy matters and organic substances, such as guano. First, it is broken up in a crusher and placed in the dissolving pans. In some establishments long four-sided cisterns are used, but the better organized works prefer closed, egg-shaped boilers provided with two moveable covers; one, the upper, for the introduction of the *caliche*, and the other for the removal of the exhausted matter.

The mass rests upon a perforated false floor, fixed at about one fourth the height of boiler, and consists of four moveable pieces on hinges. The boilers are filled up to the top with the broken raw material, and up to the half height with mother-liquor; these are heated by direct action steam, admitted by four pipes placed below the false bottom. In about two hours, more or less, the liquid is sufficiently saturated with nitre, and is let off into the settling tanks, where it rests for some hours, when the clear liquor is allowed to flow off into flat crystallizers that are fixed in an open place exposed to the wind. In recent times a second settling-tank has been added, into which the liquid is allowed to remain about 30 minutes, that it may deposit the common salt which is held in suspension by mechanical means before being run into the cylinders.

The residue which is left in the boilers, and contains from 15 to 35 per cent. of soda saltpetre is either cleared out at once, or extracted from again with spring water. The closed boilers are easily emptied by letting down the lower bottom, when the residue falls into waggons that are waiting beneath, and then are drawn away. The crystals of nitre formed in the crystallizing pans after the mother-liquor is drained away, are then spread upon a large surface that is exposed to the wind, called *cencha*, in layers of from 30 to 50 centimetres in thickness, where they are continually turned over until thoroughly dry.

Langbein gives a calculation of the total cost of a hundred weight of Chili saltpetre up to its arrival in Europe as it was in 1871 :—

Cost of production	3·25	marks
Conveyance to the coast ...	2·40	„
Cost of shipping	0·25	„
Freight to Europe	2·75	„
Charges on arrival	0·25	„
	8·90	

This was 12 per cent. more value than when W. Lloyd calculated the cost in 1868, and during the past ten years it has been greatly enhanced notwithstanding the economies effected by the application of modern machinery. Labour has undergone a change that secures for it double wages, and freights have risen. Railways have been constructed from the beds to the sea, but still a great part of the transit is dependent on mules. The following list illustrates the progress of the export trade therein :—

In 1830	18·700	cwts.
1835	140·399	„
1840	227·362	„
1850	511·845	„
1860	1,370·248	„
1870	2,943·413	„
1871	3,605·906	„
1872 upwards of	4,000·000	„

The Peruvian Goverment issued a decree on July 12th, 1873, taking the whole of the trade into its own hands, and has ordered that not more than 4½ millions shall be exported in one year. The monopoly Dr. Geyger has, has not yet shown its fruit in affecting the saltpetre trade, and therefore no decision can be formed; but we venture to think the Peruvians are destroying the goose that brings golden eggs. There are other places, as for instance Egypt and India, which, by the aid of modern science and enterprise can be made capable of supplying all that is required, to say nothing of chemical combinations that may from time to time be discovered in the way of substitution.

M. R. Wagner has published a very complete analysis of the composition of the purified saltpetre imported into Europe.

Sodium nitrate	94·03
„ nitrite	0·31
„ chloride	1·52
„ sulphate	0·92
„ iodate	0·29
Potassium chloride	0·64
Magnesium chloride	0·93
Boracic acid	—
Moisture	1·36
	100·00

The mother-liquor of the refineries contains from 2½ to 5 grammes iodine per litre, and is used in some of the Peruvian works as a scource of that article.

Travellers and Natural Philosophers have published numerous opinions on the origin of these saltpetre beds, but no satisfactory explanation. It would almost appear that the formation had taken place under circumstances unknown to the history of man. One M. H. Reck contends that Chili saltpetre is the oxidation of huge guano beds, but as Nöllner shrewdly asks, what is gone of the phosphate of lime? and suggests that storms have thrown up prodigious masses of sea-weed, all nitrogenous which have been driven into that bay of South America and produced nitrate of soda by slow oxidation.

Nöllner is right in adducing the constant occurrence of iodine in the nitrates as due for their origin to sea weeds, which are the nitrogeneous collectors of sea iodine. The saltpetre beds are on a coast where the western winds blow in force and the coast currents flow.

The result has been in the course of ages, long before history, the creation of a zone of sea weed analogous to the nitre beds of Peru already described. And here we are obliged to return to the old ground, and recognise the provision of store for the benefit as well as for the instruction of the races of men,—or the race who will give thereto its regard,—made by the Divine Artificer, whose chemistry and mechanism it is our highest honour, as it is our privilege, to seek to understand. That provision is clearly marked out : we are all of us paupers depending thereon. Our glory it is to have the opportunity of being faithful to such a trust, and thereby endeavour to make clear what every one feels to be true even when they cannot tell the reason, that while many things are hidden from "the wise and prudent, they are revealed" to those who are children loving to trace a Father's footsteps in this wonderful world.

HOW AND FROM WHERE NICKEL IS NOW OBTAINED.

METALLURGY is making astounding progress since the science of chemistry has been more generally applied to manufactures. There is not a week but reports arrive of the discovery of a new metal, the result of chemical combination or chemical treatment of ores : and although such reports must be regarded with suspicion, because they frequently emanate from an order not addicted to accuracy of representation, or the honest development even of what they possess, the mining community lay claim to a knowledge that nobody else is supposed to possess, and they also claim to have almost a monopoly in controlling the investments of those who have more money than their daily wants require.

There is, in spite of this caution, a very large, growing, and profitable scope for the capitalist and the manufacturer, under the guidance of a sound chemist, who makes it his study to acquire positive knowledge of the secrets so long hidden from man, although actually beneath every foot of the earth on which he treads : and this knowledge is of untold worth. The precious metals—pure gold, silver, and the like, are not sufficient to

supply the variety required by the elevated taste of the entire population since the extension of general knowledge which distinguishes the past fifty years.

Substitutes of different colours are now rising into general acceptance, and the combinations that are accepted as imitations of gold and silver are obtaining a position that gives them a preference to the real, because of their comparative worthlessness to the thief. Their value depends more on the workmanship than the metal, and therefore are not of any use to the dishonest.

Nickel has held the most favoured place after silver for some years, and the improvements it has undergone still enable those who trade therein to hold their own in the market. In this journal frequent references have been made thereto: as in vol. 6, p. 114, notice was taken of the paper of the Rev. W. B. Clarke, a geologist of New South Wales, read in the early part of that year at the opening of a new Scientific Society, referring to this subject, which had for some time been engaging the attention of manufacturers whose profits were being interfered with by the steady and continuous rise of the nickel market. The presence of nickel in the French Colony of New Caledonia (Australasia), had been proved by M. Garnier in 1869, and concessions been applied for and obtained from the government in favour of these enterprising manufacturers in the intervening time. In 1869 the price of nickel stood at about 5s. a pound; in 1876 it had risen to 15s. Certainly its preparation had become more perfected, and instead of being regarded as a mere imitation, its inherent beauty caused it to be more and more sought after. The ore discovered here excelled all others in that, while nickel had hitherto been an extract resulting from many processes upon amalgams that yielded other substances besides what was wanted, such as sulphur, arsenic, cobalt, and antimony, this furnished more directly what was required, for the only substances with which it was combined were earthy.

The serpentine rocks abound in that district, and these yield almost pure nickel leading to lodes of copper. After a while a load of 500 tons were sent to France, and such is its excellence that the price will probably rise to almost the value of silver, for it is in many cases more useful and equally ornamental.

The universality of this element should have led Great Britain to make more of what it possesses than has been done. Neither enterprise or science seem to have made the best of what is close at hand. The West of England and the North of Scotland yield a fair supply, but by some means—we fear it is the incurable *mining conspiracy*—results are destroyed just as they are on the point of realization. Sweden, Austria, Italy, all have aided; and German chemists have done good service in testing, and in thereby acquiring. England consumes, or sells rather, more than all others, but her children leave to the foreigner the richest of her pastures—manufacturing chemistry—a science that demands patience and perseverance, which Englishmen sometimes lack, but it also demands keenness of intellect which the Englishman has in excess. Why should we import what we ought to make? It is because our students and capitalists allow such profits to slip through their fingers. We intend to speak presently of the excellence of the New Caledonian ores, but even that does not excuse the apathy prevailing here in a branch of manufacturing chemistry that is now worth three times what it was a dozen years ago, and then was nearly all profit!

We were referring to the excellence of the New Caledonian ores; that they not only equal but far excel what is obtainable on the Continent, in Sweden, and in the Western Hemisphere, as far as we have known, is clear enough; but we regret exceedingly that it should be necessary to give the very utmost caution to the practical reader who might incline to venture his capital in their use. No honest source of supply ought to hesitate about guaranteeing twelve per cent. at least from the ore: but if the purchaser will submit to be bamboozled by men of straw, backed by puffing pseudo-scientists, they must count in all their calculations on a loss of money, and perhaps also of patience. The guarantee should be positive, and the guarantor unimpeachable.

Nickel works are said to be hidden from ordinary inspection. In that respect they differ not from every other special manufacture. Visitors are not always honourable; they will avail themselves of hospitality that gives them a footing in premises they do not hesitate to rob for their own advantage of all that has built that by which they have just been fed. But nickel collection has no more mystery than ordinary transformations of nature. Our readers will see in the *Practical Magazine* vol. 6, p. 341, the general treatment of nickel ore as described by Kuntzel. To that we have somewhat to add.

Almost every one of these ores, as they come before the public, either as original, or by process of resurrection, are associated with a kind of pedantic patronage that is only half original. One would not mind their being only 50 per cent. of what they seem to be, if due tribute of recognition were awarded to those who have previously laboured. In fact, if there were 25 per cent. only—which is generally the utmost a modern brings—if he would but say the 75 belongs to "ancestral glory," he would be cheered by all; for he who but "adds a line unto the story" deserves human love, and he would have it generously.

The student will perhaps hear as a wonderful discovery, that after much and painful observation, the philosopher found delightful relief in observing the power of acids in decomposition. Was ever such a remark made before? Yes, unfortunately. But a boy knows there is no other way; and it needed not parading to announce what every tyro would have his ears boxed for not finding out by himself. One says that after much consideration and patient thought his mind had arrived at the selection of sulphuric acid, in preference to all others. Why nobody ever did any thing else! What says Ure (1870).?

"*Nickel may be detected by cyanide of potassium* in an *acid* solution of it and cobalt; the cyanide being added until the precipitate first formed is re-dissolved; *dilute sulphuric acid* is then added, and the mixture warmed and allowed to stand," &c.

We are also told by a modern philosopher that such a method is preferable, as his personal knowledge and skill has taught him, to the use of hydrochloric acid: on which subject Ure, quoting from H. Rose, describes a successful method. But look at his words and see whether the old is not as good as the new advice. "Both metals are dissolved in hydrochloric acid: the solution must contain a sufficient excess of *free* acid; it is then diluted with much water," &c. And he goes on to describe minutely, in respect not only of nickel and cobalt, but of iron and manganese, of which particulars may be found in a very valuable book by Watts, entitled "Dictionary of Chemistry."

The fact of the matter is that every description of ore requires special treatment. What is obtained from Sweden is as distinct as possible to that in Austria. Our Cornwall product has no resemblance to that of the Shetland Isles: and that which is the favourite at the present time—and justly so—is of a character more differing from each than they from each other. So will it be in reference to all others as they are discovered: now that chemistry has turned its gigantic force into a metallurgic current new metals must be formed, and the old ones be greatly improved. Every treatment is good in its way, and the New Caledonian being more of earth than any other, is amenable to a treatment that is utterly useless if it were applied to the ordinary material of which European Nickel has been commonly derived. There must be an abundance of such material in this universe, and therefore a full knowledge of the treatment adopted will be of more ultimate service than the long, varied, and somewhat risky processes that have been demanded hitherto for the manufacture—or rather collection—of this useful and singularly attractive metal. Just as in the medical world, physicians three hundred years ago produced from decoction what modern chemistry obtains in concentrated form, so are we acquiring skill in metallurgy which is already astounding, and will be more and more.

A review of what has been done in the production of nickel supplies many excellent and practical suggestions, all of which tend to indicate the development now attained. In 1859, Mr. T. R. Russell in his patent (2735) showed that nickel, and the alloy of nickel, could be applied to the movements of watches and all other time-keepers, and be of equal if not of superior service when compared with the metals and alloys hitherto used for those purposes. That idea is nearly twenty years old, and now it is very extensively adopted, because the material is really the best that can be employed.

Muspratt, the distinguished chemical manufacturer of Lancashire, showed in 1857 by his patent (1589) that nickel, cobalt, and copper could, if combined with manganese and iron, be obtained from the waste liquors in his works. He separated the nickel, copper, cobalt, and oxide of manganese from the ores used in making chlorine when in solution, first by extracting the iron as a peroxide by the use of carbonate of lime or its equivalent. This he decanted, and by sulph-hydro gas the sulphuret of copper was thrown down. The impure sulphuret waste, properly treated as he directs, makes nickel and cobalt, if *lime* be used. Here is a clear teaching of what is now often put forth as a new discovery.

And Thomas, as far back as 1854, could plate lead and iron with nickel *by the aid of sulphuric acid* or gas. In 1853 Ricolz and Fontenay patented (3026) an alloy that is singularly clever. Of silver he took 20 parts, of nickel 75 to 30 parts, and of copper 75 to 70, which copper was of the purest in the market, and these *he combined* by the use of sulphuric acid with currents of chlorine, and boilings of *lime*. This recipe proves that the greater part of our knowledge is at least twenty-five years old.

We have mentioned the name of Jules Garnier who was described by Mr Clarke as the inventor or rather the discoverer of the merits of this New Caledonian ore. He patented his process for its treatment and attached his own name to the material. An impure cast nickel is obtained by melting the ore in crucibles with carbon and appropriate fluxes. The smelting is done by means of a blast furnace, like that used in iron foundries in the production of pig-iron; and tapping off the molten metal according to the instructions laid down by Mr Bessemer, and explained in our journal for April 1876, by means of what is called "a converter." He has undoubtedly gone far to produce a nickel of marvellous hardness thereby; and there is little risk in anticipating that either he or some one working "upon his lines," will ultimately give to us a material that shall equal iron in its useful applicability, and be free of the terrible oxidation which militates to its immense disadvantage. We don't see why such a result should not be reached.

And previous to that the well-known Mr. Alexander Parkes of Birmingham began his treatment of metals that could yield the best nickel. He is referred to in every treatise or lecture on the subject, but it is not generally understood that his labours have extended over thirty years, and that he is practically the teacher of all who by art have improved white metals; and that to him the world is indebted for the best method of treating the New Caledonian ores. In his patent, dated from Birmingham, he especially aims at the desirable qualities of hardness and brightness. He claims that by his invention he can obtain an alloy of nickel, copper, and iron by fusing oxydised compounds of nickel with oxide of copper fluxes, and carbonaceous matter. To a ton of ore, of guaranteed quality, he puts 4 cwts. of fluor-spar, 56 lbs. of rock-salt, 4 cwts. of copper scales, and 2½ cwts. of anthracite. These are placed in a reverberatory furnace for five hours and subjected to a powerful heat. At the end of that time from 2 to 4 cwts. of granulated metallic copper is added, and kept spinning for another hour, when it is tapped and run into moulds as usual, or the scum is removed and the mass thrown into water.

This rough stuff is then refined by remelting, say a ton, and adding 2½ cwts. of copper scales, 1 cwt. of sand, and 56 lbs. of lime under an oxidising atmosphere. This copper-nickel has surprised every one, and bids fair to be a great commercial success when the improvements now making are accomplished. It is a great success at present, but the perfection now sought will give it pre-eminence.

Mr. Parkes' patent covers another method of treating this description of ore, namely, the old principle of fusion. He combines with it fluor-spar and carbon, adding sulphur, sulphate of barium or calcium, thereby obtaining a sulphate of iron and nickel that can be employed in the ordinary processes for the preparation of nickel; and there is no doubt that the method has for many purposes especial advantages which, when the further tests now proceeding at Birmingham are completed, will issue in more definite description than is as yet possible.

Technically, there are two ways of producing nickel, called dry and wet. Details vary according to the opinions of the metallurgist, or the nature of the ore to be treated. The dry method is seldom used; the other is much more general; but occasionally the two methods are combined as in Christofle's experiments. If the raw material contains copper, an alloy of nickel and copper is produced; and if otherwise, metallic nickel. The curious fact that recommends the choice of this substance, is that although most like unto silver, especially when alloyed with copper and zinc, it is not discoloured by sulphuretted hydrogen as silver is. Again arsenic will induce brittleness and liability to tarnish. Iron, sulphur, and cobalt combined give hardness and colour with excessive brittleness.

Marketable nickel, when alloyed with copper, is sold in the cake form like copper, but otherwise in small cubes which are made thus:—Hydrated oxide of nickel is mixed in a pasty mass with about 5 per. cent of rye flour, some beet-root syrup and water. This is all beaten into a frame and cut up into cubes of about half to three-quarters of an inch, which are slowly dried. They are then put into crucibles surrounded by coal dust, and are gradually made of white heat till they cake together. Nickel melts at about 1900° or 2100° C. and cannot be fused in the common metallargic furnaces, but with ten per cent of copper and a small quantity of sulphur, nickel is rendered fusible in a good air furnace.

To show the skill required in its production, we quote Kerl. "Pure nickel when taken from the reduction glasses possesses metallic lustre, and if drops of glass adhere there is alkali. If those drops are blue it proves cobalt, and if yellow, iron, to be present. If there are black drops, that on being moistened evolve sulphuretted hydrogen, it proves that the alkaline sulphide has not been properly abstracted. But when the cubes are dull-looking, revolving them in water casks will give them polish. Hence although crucibles are usually employed, some prefer the reverberatory furnace furnished with vertical tubes whereby the cubes may be removed from the bottom and recharged.

"In producing nickel by the wet method there is a previous roasting of the ores, matte (a crude black copper reduced, but not refined from sulphur and other heterogeneous substances.) This roasting makes oxide of iron which is nearly insoluble; and copper nickel and cobalt, soluble in water by causing them to be sulphates, or soluble in muriatic or sulphuric acids by transferring them into basalts or oxalic crystals."

Kerl further describes how re-agents are employed to extract nickel in the wet way. These of course must be cheap, and are, 1. Carbonate of lime that has little or no iron, used in the form of powdered chalk. This commonly begins the precipitation.

By it there is a possibility, when using it at different temperatures and precipitating it gradually, to separate, first the iron and arsenic, and then the copper, leaving the nickel alone. If precipitation is at boiling heat, the iron in the lime will remain in solution unless highly oxidised by the addition of chloride of lime.

Lime water is also used both for the precipitation of nickel alone, or for copper and nickel together, after the iron and arsenic have been removed by the carbonate of lime and the cobalt by its chloride.

But when employing these simple lime compounds and dissolving in sulphuric acid, or after forming sulphates from matte roasted, the precipitated nickel contains gypsum, and that is not easily removed, carbonate of soda must be employed in fractional precipitations. A small quantity is added to a solution of peroxide of iron, oxides of copper, nickel, and cobalt, and continually stirred; a basic salt of the former will be percipitated before the solution is neutral, then a mixture of peroxide of iron, and oxide of copper, then of oxides of copper and nickel, and last, pure oxide of nickel with a little oxide of cobalt. The remaining solution contains oxide of cobalt and nickel in small portions. But if there be so much as 3 or 4 per cent. of copper no nickel can be precipitated. Sometimes iron is used for precipitated copper; and acid sulphate of potash for precipitating nickel from cobalt solution, and nitrate of soda for separating cobalt from solutions that contain nickel. We need not herein particularise further the process of extracting nickel from speiss, which is a compound of nickel, sulphur, and arsenic, found at the bottom of crucibles used in other manufactures, further than to say that the oldest and most modern employ muriatic, sulphuric and other acids—a method we have before spoken of as being treated now-a-days as if it were a discovery, whereas it is as old as the metal itself, and does not belong to any body alive. Roast first, then dissolve with acids and finish with lime or lime water; these rough words contain the whole secret; the specialty will depend on the nature of the ores, and the purpose to which the nickel is devoted.

Almost similar is the treatment of matte; the matte must be roasted by itself first, and then with sulphate of iron and sulphuric acid. It is then lixiviated with water and accompanied by chemical treatment, when it yields pure oxide of nickel, and a solution of Glauber's salt. Then if nickel-copper from the solution is desired a valuable product results. Oxide of nickel, hydrate-oxide of copper, and a little watered oxide of iron are precipitated by lime water pressed in canvas bags and dried, ground, and sifted. It contains 8 per cent. of gypsum if muriatic acid is applied with water in the proportion of 4 lbs. to 140 of the ground stuff. Lime water is applied to the resulting precipitates, and the furnace used. In the end 73 per cent. of nickel is yielded with a fraction of iron. The residue of this process is formed into a paste and mixed with sulphuric acid, and under the subsequent treatment there issues 40 per cent. of copper, and 5 of nickel.

All the subsequent processes depend on the use of acid, and the final purification also. This is not a novelty, and we have merely stated the broad grounds to prove that when moderns are surprised that nickel is the product of acids, they speak of knowledge familiar to the world forty years ago.

It would be a waste of words to show how all these old ideas are reproduced under various disguises, and how every one who desires fame trades upon the old grounds. All modern chemistry goes in for high temperatures, just as steam must have high pressure, but there is no inherent novelty in all that; it is merely an adaptation, or at best a development of acquired knowledge and recognized facts. There is a tendency to confusion in attempts to create originality that is to be deplored; a mixing up of matters irrelevant, or the experimental attempts that have no value beyond the words employed to describe them. The old muffle is fine; you know what you are doing. Mixing is so very often muddling, that one had better learn that whereas all mixing has been done pretty well by the patient

investigators of the passing generation, there is nothing left for the modern but to find out,—if he can,—something new. Oracular utterances cannot be accepted otherwise.

Nickel is undoubtedly to be produced in larger quantities than it has ever yet been. We have in the course of the last year witnessed the rise of waste of all kinds into marketable commodities, and this particular result of metallurgic science can be multiplied indefinitely as the demand shall grow. That it will grow, proofs abound: that it is wanted is equally evident to the manufacturer of domestic and other goods in imitation of, and in some respects superior to, silver, is clear. The rise in price is something like 400 or 500 per cent. already, and at such a rate the nickel manufacture is not likely to want capital or intelligence to carry on its wonderful career of beauty, value, and profit.

A NEW AMERICAN LOCOMOTIVE.

GAUGE is a question that will occupy engineers for some time yet. Much has been effected toward its solution, and many theories have been proved unsound; still with the restlessness of the American character and the conditions of engineering in that land of wonder and novelty, one cannot affect disappointment that no more has come from the countless experiments. Every invention is connected with enterprise and capital, and has its rivals who, with more or less of scrupulousness, defend or attack as best seems befitting their wisdom or their interest.

A two-feet gauge has claims there that it would not have here, and as we have been favoured by our contemporary the *Engineer* with an illustration,* supplied by the *American Railroad Gazette*, the principles may be profitably referred to, and the design and working described. We have long known that four-wheel engines and narrow gauge lines are really more useful than those having six wheels, or running upon broad-gauge. The four-wheel switching engine has the entire weight of boiler and machinery thrown upon the driving wheels. It weighs only twenty tons, but it will pull as great a load as an eight-wheeled engine that weighs thirty tons, simply because one-third of the weight of the large engine is on the leading track, and the whole weight of the smaller engine is on the driving wheels. The reason why the four-wheel engine is not more used is because the wheel-base being necessarily of comparative shortness there is caused an unsteadiness when at high speed, or travelling over roughly finished lines. And the wheel-base cannot be lengthened so as to utilise the whole weight on the wheels because of the necessity of connecting them together by cranks and rods to make a common revolution. Cranks must be of the same distance apart, and axles be so constructed as to be parallel to each other. If a pair of axled wheels roll on a curved line the centre of the axle must be the same as the radii of the curve, or the wheels will not roll either in parallel or in line with the rails. If axles are not radial to the curve, the wheel flanges come into collision with the rails *in due proportion*, and that is not profitable. And, if pairs of wheels are connected as described and the axles are in a frame held tightly parallel, if those wheels are on a curve and the axles are parallel the curve of the radii cannot be kept. The whole is unsteady. Suppose that a common horse tram has to go round short curves that are contiguous, it acquires a jerking motion when in contact with the machinery if the speed is at all rapid; indeed it is dangerous, and therefore the four-wheeled locomotive is not employed for difficult but only for slow traffic.

This has led to the creation of "bogies," as described in past numbers, that are intended to run at any high rate of speed. In the engine illustrated, by turning on the centre pin the truck is adjusted to the curve, and, as the wheels are near together and their base is diminished, the angle of wheel and rail is reduced, and, of course, the engine is on wheels that are nearly parallel to the rails.

Mr. Forney patenteed the ingenious plan we have referred to by the engraving, by which all the weight of the boiler and machinery is upon the driving-wheels, some years ago; he has extended the frames backward beyond the fire-box, thereby providing room for conveying water and fuel by a truck underneath, thereby dispensing with a tender and utilising the whole weight of machinery, boiler, and fuel because it all fell upon the truck. The plan is called American. It is not. Our relatives on the other side of the Atlantic use their ancestors' inventions without much scruple. "Bogies" under the tank have long been used in Great Britain, but that is neither here or there. Mr. Forney runs his tank in front, which is the reverse way, and his plan is adopted on the Billerica and Bradford Railway in the United States. Here are the dimensions of his engine—

Gauge of road	2 ft.
Diameter of cylinders	8 in.
Stroke of pistons	12 in.
Diameter of driving-wheels	30 in.
Total wheel-base	13 ft. 0 in.
Driving-wheel base	3 ft. 6 in.
Weight of Engine with fuel and water	23,750 lb.
Weight on driving-wheels	14,350 lb.
Weight on truck	9,400 lb.
Capacity of tank	400 galls.
Inside diameter of front end of boiler	30 in.
Diameter of dome	18 in.
Length of fire-box inside	30 in.
Width	27¾ in.
Height	37 in.
Water space	2½ in.
Number of tubes	70
Diameter „	1¾ in.
Length „	6 ft. 7 in.
Thickness of iron plates in shell of boiler	5-16 in.
„ steel „ sides and back of fire-box	¼ in.
Thickness of steel tube sheet	⅜ in.
„ „ crown „	¼ in.
Size of steam ports	6 × ¾ in.
„ exhaust „	6 × 1¾ in.

The driving wheel tires to be of steel, the main parts to be flat or without flanges and 5½ in. wide, the other pair to have flanges and to be 5 in. wide.

Thickness of tires	2 in.
Diameter of wheel centres	26 in.

Size of journals, 4 in. diameter × 4 in. long.

Truck frame to be of wrought iron forged solid, the jaws of cast iron.

Diameter of chilled cast iron truck wheels, 18 in.

Truck axles to have outside journal-bearings 5 in. long × 2⅝ in. diameter.

Engine to have one No. 3 and one No. 4 Mack's injectors.

A feature in these engines which is worthy of notice is the width of fire-box. With the ordinary methods of construction employed in the United States, the fire-boxes on all engines, but especially on those for narrow-gauge roads, must be very much contracted. If the usual plans were followed in engines for a 2 ft. gauge road, the fire-boxes would necessarily be contracted still more than on a 3 ft. gauge road. For the present case, however, the wheels are placed entirely beyond the fire-box, so that it can be spread out as wide as may be desired, and the frames are then abutted against the fire box and attached to it with an expansion joint, so as to allow the boiler sufficient room for the movement which is due to expansion and contraction from heating and cooling. The frames which support the tank, and which rest on the truck, consist of flat plates strengthened with angle iron, and are bolted to the sides of the fire-box. This method of construction is admissable for an engine of so small a size, but it need not be resorted to for engines of a much larger size for the standard gauge. It will be seen, however, that it gives all the width of fire-box that is needed, an advantage which, it has been claimed, can only be realised on narrow-gauge roads by use of the double-truck engines. As regards the performance of these engines, the general manager of the line writes: "The new engines on the 24 in. gauge are a double success. They pass the curves on the Y, 127 ft. radius, with ease. They make more steam than is wanted, and use but little coal. We have been burning hard coal the past week, and have made a speed of thirty-five miles per hour on our rough track. The side oscillation is done away with entirely. We ran passenger trains four days last week with the greatest satisfaction, the cars riding smoothly and with perfect ease and no side oscillations. We have never had any hot boxes on any of the cars since running, or on the locomotives. Last week we ran a train seventy-two miles each day, at a cost of 13c. per mile. This includes all help, fuel, oil, and waste, using less than ¾ ton of coal. The weight of train including engine was 23½ tons, the weight of cars, 11½ tons, with seating capacity for 100 passengers, which number we carried on some trips. One of the cars was a combination baggage and express car. There is one grade of 158 ft. per mile, two of 100 ft. one-half mile each long, and numerous other grades of 40 ft. to 90 ft.

As regards the rolling-stock, it is carried on double four-wheeled bogies. The box and flat cars are 22 ft. long over the body and 6 ft. 2 in. wide, or more than three times the width of

* See Frontispiece.

the gauge. The weight of the box car is 5600 lb., and the capacity 16,000 lb. The flat cars weigh 4500 with the same capacity as the box-car. The excursion cars weigh 5500 lb., and have seats for fifty-five passengers. The road has one box-car, six flat cars, and two excursion cars.

PROCESSES FOR PRESERVING TIMBER.

AMERICA has at last found that she cannot afford to be indifferent to the consumption of her forestal timber, and many patents have been taken out in protection of special methods for securing timber from the effects of time and circumstance. The rapid consumption of wood has led to inquiries as to the cause, and the investigations all point to methods that aim to be successful in arresting and preventing decay. England, and indeed Europe, have long employed various processes, severally designated pickling and preserving, but, perhaps, a little review of what is now being done in America may serve to confirm or correct our own knowledge by the light of their experience.

France has been especially fortunate in having the service of M. Paulet, who, in an octavo volume published in 1874, mentions a hundred and seventy-three different processes and apparatus that have been patented since the year 1700; but it is to modern chemists we must look for the most efficacious methods, because modern chemistry has produced results utterly unknown before. Corrosive sublimate, creosote, chloride of zinc, and sulphate of copper are the successful ingredients, and these so used are not fifty years old.

Few of our English engineers would use timber in its raw state: they will have it "pickled." The sulphate of copper or the creosote oils must be employed: we cannot afford to have the perpetual inconvenience and interruption consequent on the use of green woods, nor have we a wealth of timber that can be recklessly drawn upon. We must be economical, and in being economical it is to be noted that we are securing better material as well as more enduring. In every part of the world there is evidence that timber must not be wasted. The supply is not inexhaustible: the drain is enormous, and even in the Western Hemisphere many districts have become absolutely disforested. So is it at home, and therefore what wood we use must be so used as to prolong its service to the uttermost. *Scribner's Monthly*, an American publication, states that the annual produce of green wood is ten thousand millions of feet, of which a vast proportion goes to replace what was cut half a dozen years ago and has decayed.

Railroad ties or sleepers are of course one of the chief consumers, and the way in which they have been wasted is little less than scandalous. We use here only pickled ones, but in Massachusetts chestnut trees have been felled by thousands and used in their absolute greenness, only to perish in a very short period, although that wood is so fine and precious. It uses yearly more than the whole produce of the State; and it is a fact that railway sleepers take one-sixth of the entire timber produce. Add to this the wood for fences along the lines, the bridges, the platforms, the stations, and it is easy to reach the conclusion that until economy is practised most vigorously the supply will soon become insufficient.

Again, in America there are about 80,000 miles of telegraph poles, requiring for renewal an annual supply of four millions of feet of wood, and these have not been creosoted there, but they are here, and have been during the past five-and-twenty years, to an enormous saving not only of wood but of the labour attendant on reconstruction and in formation. Every one who uses wood should use some method for its preservation, for the cost of wood is certain to increase enormously under any case, but most rapidly if it be wasted or uncared for.

There are two kinds of decay in wood, and these are known by the terms dry rot and wet rot. The latter occurs in wood containing sap that is exposed to moisture, and it will commence in the living tree. When the tree is felled there are sometimes red streaks in the wood: that is wet rot that has begun its terrible ravages on the living tree. Such timber cut up into fences, sleepers, poles, and bridge beams and girders and exposed to alternations of moisture and heat is sure to perish in a very short time unless some preserving process is resorted to.

But dry rot also is developed by moisture. It occurs in close, confined, damp localities that are ill ventilated, and especially when the timber has been used hastily without a due and reasonable seasoning. It occurs in cellars and basements, and between ceilings and floors. Houses rattled up by speculating builders are specially liable to its influence. The deal rafters, joints, and what not are brought in hot haste from the sawmill after, perhaps, only a week's cutting down of the tree, and are absolutely reeking with the sap and moisture. Dry rot is contagious: when once it begins it is communicated to wood not at all raw or green. This has been seen in our old-fashioned "wooden walls," and the last perfection of shipbuilding consisted in using only timber that had been properly prepared to resist its attacks.

If one inquires what is the cause of dry rot and wet rot, the answer is that primarily it is attributed to the fermentation of the albumen of the sap, and it commences as soon as heat and moisture are applied or generated. In a living tree the unmatured sap rises from the ground through the sap wood, and after being transformed by the action of the leaves into true sap for the formation of woody fibre, descends within the bark loaded with sugar, acids, albumen, and the like that forms the annual growth of wood, and holds in abundance rich sap within its cells and fibres. This is all very well while the tree lives, but when it it is cut down and the leaves are hindered in their functions the sap clogs the pores, and soon heat and fermentation are generated. This fermentation causes a prodigious development of fungi; animalculæ and insects follow, and the woody fibre is disintegrated and decays, losing all strength and tenacity. Fungi and parasites produce rot. Therefore it is against the development of fungi and parasites the wood preserver must guard. Metallic salts will cause the coagulation of the albumen of the sap and prevent fermentation, besides rendering dormant the spores of fungi in both vegetable and animal life. This especially refers to protection against dry rot, where the wood is not exposed to moisture.

Creosotes not only act chemically upon the sap, but as they contain carbolic acid, cresylic acid, and the like, they secure dryness by filling up the pores with an insoluble oil that covers the fibres with a film that protects them from absorbing destructive elements from extraneous sources. The oil, which saturates the sap, wood, and the outer pores of the heart wood *resinifies* and hardens under the action of the air, and forms a waterproof and air-tight covering to the wood. These advantages give to creosote oil a superiority over every other substance used for preserving wood, because dryness is induced. Heat and moisture must be in combination to produce decay. Separate, they are harmless. If wood is absolutely dried by artificial desiccation it will not decay, provided that dryness is maintained, and hence such wood never does decay. It may wear out, but that is the only destruction that can occur.

The great desideratum is to find some effectual method of drying green wood rapidly. In England we stack railway timbers for nine or twelve months, and thus season them before applying creosote, and the experience of one of the best authorities here, John Bethell & Co., says that "Dryness is the principal quality required in timber that is to be creosoted. Timber is sometimes delivered dripping wet, and the creosoting is expected to be undertaken by the trading firm instantly. Better not creosote at all than creosote moist wood."

In America time is regarded as the chief factor. Whatever is to be done must be done at once. Blundering of course frequently results, but the reckless impetuosity of temperament which characterises that people leads to most unreasonable attempts and sometimes to great discoveries. Timber is there used the moment it arrives. If the saw goes in it is for supplying constructive materials to the size and at an hour's notice, and only a few hours will be permitted for seasoning and the application of preserving processes. Hence the Bethell system does not avail. Oil and water will not mix together. Pores of wood reeking with sap and water will not receive any preservative substance, and hence what is known there as the *Hayford patents* is strongly advocated.

This process claims to secure *dryness* before impregnation with any preservative substance, a complete coagulation of the albumen of the sap by heat, the evaporation of the watery portions of the sap, and the withdrawal of all moisture, sugar, acids, and the like in vacuo, leaving a pure wood fibre fully preserved against decay, except from contact with air and moisture.

The specialty consists in apparatus, not in the materials. Creosote could not be monopolised by any patentee. Mr Andrews describes that in use at his works, South Boston, Mass., U. S., as simple and strong, and he adds with American enthusiasm that he has endeavoured to attain perfect security from accident, and at the same time possess the best fitted and strongest plant ever erected for wood-preserving.

"It consists mainly of an 85-horse boiler, a pump, a tank to contain oil, and a cylinder on which the wood is treated. The *cylinder* is the most important part of the works, and upon its perfect construction depends the commercial success of the enterprise. It is 100 ft. long, 65 ft. in diameter, is made of ½ in. boiler iron steam riveted. On either end a cast gun-iron ring

is riveted, which serves as a jam to a wrought-iron door made of plates of 5 in. thickness, bent to a semi-globular form and riveted to a gun-iron ring of the same dimensions as the ring in the cylinder. This door is hung to the cylinder by a hinge which acts as a guide only, the weight being supported by a strong wheel that rolls on a track with a solid foundation. A rubber washer makes the joints tight, the cast iron rings are pierced with bolt holes through which 36 bolts pass. On one end of each bolt is a case-hardened nut, and at the other is pierced an eye, into which slips one of a series of steel keys arranged upon a ring that revolves about the cylinder by a screw motion by which all the bolts are fastened or unfastened at once. A few turns are given with a wrench to the nuts to make all tight before beginning, or to loosen when it is done.

"The cylinder rests on rollers to allow for expansion and contraction: these are supported on brick piers. This cylinder is perfect in construction, and bears hydrostatic pressure of 200 lbs. to the square inch. There is no leakage as there has always been in previous apparatus. A railway-track, 3 ft. 4 in. wide runs through this cylinder, and extends 100 beyond at each end, so that iron cars can be loaded with the green wood at one end, and be discharged at the other. Between the rails at the bottom of the cylinder, there lies a coil of steampipe 1400 ft. long, connecting the boiler at one end, with the outlets for communicating with the outer air and the inside of the cylinder, that the steam, after passing through the coil, may escape into the cylinder if that is desired.

A series of perferated pipes is arranged round the inside of the cylinder, for the purpose of introducing the oil. These are connected with the oil-tank, and are so arranged that when the oil is let on through them, every piece of wood in the cylinder is at once bathed with oil.

The oil-tank is merely a receptacle for the oil, and made large enough for that purpose, of sufficient strength to bear a pressure of 100 lb. to the square inch. A coil of steam-pipe connected with the boiler is laid through it for heating the oils to the necessary fluidity. A simple and powerful pump provided with valves and pipes so that by opening one set it is a force pump, and by closing those and opening another set it becomes a vacuum pump. A water-jacket round the air-chamber keeps it cool while in operation, and there are the usual pipes connecting the parts together.

The process commences by drying the timber. The wood is placed on the iron cars or carriages and run into the cylinder which is hermetically closed. Steam is then admitted through the coil in the cylinder and after passing through it enters the cylinder which soon reaches a temperature of 180° Fah. It rises very slowly from this point because the evaporation of the sap and moisture in the wood tends to lower the temperature. This heat must increase gradually and be kept moist or the outer fibres of the wood will harden before the inner moisture is exhausted. The exhaust pump is therefore used to force atmospheric air into the cylinder until the pressure guage shows a pressure of 30 to 40 lbs.

Mr. Andrews has shown that to preserve wood from decay it must be rendered non-fermentable by the coagulation of the albumen of the sap: that dryness must be secured by the abstraction of the sap and moisture, as well as any sugar or acids that might ferment: that dryness and a woody fibre being secured those conditions can be maintained by a process of protecting the wood from air and water afterwards.

Albumen coagulates at 140°, and all the sap containing albumen is in the sap-wood, which if steamed to 240° or 270° Fah. renders the albumen non-fermentable. Creosote oil contains the most powerful coagulator of albumen—carbolic acid: hence, when injected into the pores of the wood, fermentation is doubly guarded against.

By steam heat and the use of the vacuum pump the sap and water held in the wood are vapourised and withdrawn from the pores of the wood, leaving a pure wood fibre with nothing to ferment. This system of drying can be of great use to carpenters, for in twenty-four hours green timber can be seasoned more thoroughly than by a six weeks in the drying-house. Drying must be kept up for some time after the vacuum has been reached, by using a radiating coil of pipe.

When freedom from any risk of fermentation and dryness have been secured by the early processes, the wood is made water proof and air-tight by injecting the pores with creosote oil. These creosote oils are called dead oils, or the heavy oils of tar. They contain about 10 or 12 per cent. of carbolic acid, and several other highly antiseptic and preservative constituents, besides paraffine, napthaline, etc., which all assist in the preservative process. Heavy oils are produced in the distillation of crude coal-tar as it comes from the gas-houses. They come off after the light and volatile aniline oils, at a temperature ranging from 300° to 600°. The residuum is pitch.

Creosote oil, forced into the pores of the wood at a high temperature, being far more penetrating than any other oil, works its way through the pores until it covers every fibre with a protecting film. It resinifies in the outer pores and keeps the main body of the oil within; and, being insoluble in water, forms a water-proof and air-tight covering to the wood which, however exposed, is protected from absorbing any fermentable substance, and, of course, decay is almost impossible.

The preserving qualities of heavy tar oils are not due to one or more of the component parts, but chiefly to the thick greenish oil itself, which is insoluble. This insolubility gives them their superiority over chloride of zinc, sulphate of copper, or corrosive sublime. These only coagulate the albumen and afford no protection to the wood, the fibres of which are exposed to absorb destructive agents as much as ever. But when wood has been thoroughly creosoted the oil working insidiously through all the fibres, the albumen is coagulated and the whole structure rendered indestructible except from wear, and becomes harder by the lapse of time. The oil seems to metalize the fibre and make it like iron. Soft wood becomes as hard as oak, and sap-wood as durable as heart-wood.

This property has been known in England these forty years, and all our engineers have adopted the process in railway sleepers, timbers for bridges, and the like. In fact they do not decay: they are after twenty years of wear removed, but are sound and harder than ever. In America it is found that creosoted wood is safe from the ravages of timber insects, such as the Teredo Navalis, or the Symmoria Terebrans.

THE ART MANUFACTURES OF JAPAN.*

PERSONAL OBSERVATION is the only trustworthy source of knowledge concerning other countries, and this is the virtue the lecturer claims as his special right to an audience. The learned gentleman should, however, remember that there is no other source; for books are but the reports of what eyes have seen, or what minds have observed.

There are some facts herein reported which we will extract, omitting the complimentary and egotistic portions as of not sufficient practical value to the public who seek to know what is doing or what can be done. For instance, to affirm of the patronage of the Royal Family, "With it any art will progress; without it the most noble of crafts may perish," is too much. The world would be in a sorry plight if there was a millionth part of a shadow of truth in such a statement. Art depends primarily on individuals: and for the most part the Royal Patronage does almost as much harm as good, except as it draws out the wealth of the ignorant rich for the good of large manufacturers, and the gratification of the spender.

Dr. Dresser left Liverpool in October 1876 under a commission from Messrs. Londos & Co., who are the largest importers of Japanese art objects, to collect specimens of every kind, and collect information as to the manufacture and materials connected therewith. He went to the Philadelphian Exhibition, and thence to Japan. In a previous article much has appeared in these pages on this subject, and therefore our extract now must be only in reference to new aspects or novel information.

"Nothing impressed me so much . . . as the smallness of everything. The pottery of Owagi was large in comparison with most of the manufactories, yet it could only turn out one decorated service a year. Generally speaking the entire manufacturing staff consists of one man, or a father and son.

"The most interesting wares are made in this way:—In a lowly little room dwelt the potter: no furniture is used except the thick mats common to the country, of the size of 6ft. by 3 ft. One mat being removed, a potter's wheel was exposed to view. The wheel is of the simplest character—a mere circular stone, of the form of a Cheshire cheese, sunk in the floor, and working on a vertical axis fixed on a log of wood beneath. At one side of this wheel is a clean tray having upon it a lump of clay. At the other side is another, often lacquered, on which the vessels are placed as they are made.

"The operator kneels in front of the wheel, sitting back on his heels, and sets the disc in motion by whipping it with the tips of his fingers till enough rotatory speed is obtained. He then places a piece of clay upon the wheel and gives to it form in the usual manner, stopping to whip the stone whenever it is necessary that the speed be more rapid. Thus he shapes his wares.

* Lecture delivered before the Society of Arts by Dr. Dresser on Art Manufactures in Japan from Personal Observation.

"Sometimes the potter will, after removing the vessel from the wheel, distort its shape, and thus substitute an artistic quaintness for the ordinary symmetry. These artists gain a repute when by their skill they catch the taste of the buyer.

"Burning is generally beyond the means of one manufacturer, and therefore public kilns are scattered about where the workers can take their goods, have them fired and returned at stated intervals periodically. In many cases the potter turns out his wares quite plain, and sells his production to artists who often reside at great distances from the potteries: for instance, nearly all the enamel blue ware is painted in Tokio on vessels made in Seto, about 300 miles distant. These artists keep a little shop or stall where he attends to his customers, and paints his wares as necessary. He fires his own paintings in a circular kiln about 18 inches high, and 15 in diameter, having a domed top.

"Having painted enough pieces the kiln is charged, and the small charcoal by which it is heated is lit. The man lights his fire, and smoking his little pipe which requires filling every few minutes, for it is very small, sits contentedly till his wares are 'fired.' These are the best potters; there are a few, and the number is growing, that aim at a more rapid and large production, but the goods are very inferior in design and of low price; besides which the character of the true Japanese ware is gone."

Dr Dresser visited a town devoted to the production of curious scarves and fabrics, whereto in old time the highest merit was attached, and gives us a description of the manufacture.

Two pieces of white silk-crape are taken each about three yards in length and twelve inches wide, the usual width of native cloth. These two pieces are placed together, so that one is exactly over the other; thus placed apparently they form one fabric, indeed one forgets there are two thicknesses, for they are both treated as one, and the two are manipulated together so as to effect the saving of labour. A small piece of wood resembling a meat skewer, and a quantity of waxed thread are the implements employed.

From below a small portion of the fabric is pressed upwards on the point of the skewer into the form of a little cone of about half-an-inch in height; this cone is kept in form by the waxed string being wrapped around it; the skewer is then withdrawn and removed about half-an-inch from this little tuft, where it is employed in raising a second cone, which in its turn is wrapped round by the waxed thread. This formation of little tufts is repeated till the entire fabric is covered with them, and therefore is ready for dyeing.

It is taken to a dye vat containing generally scarlet or pink colouring matter, and is there dipped, the object is to give colour to the cloth and also to shrink it; hence, where the dye comes into contact with the crape, the shrinking ensues and permanent conical eminences are formed. The waxed thread is now removed, each little tuft being unwound, a curious fabric has been formed with a surface containing conical eminences, but also a fabric variegated in colour; for where the wax thread was in contact with the crape the dye could not act; thus by one operation a fabric is produced, both variegated and of a rich coarsely granulated character.

These scarves were worth about twenty shillings each, and were such as any lady might covet; the manufacture has been almost destroyed by the English and Americans bating the price by a systematic "knock out," until the commercial return made all honest work impossible. Japanese art is not lost; nor the taste of the people or workers destroyed, for remunerative prices will still attract the highest quality of goods.

This process of tying the cloth into knots, is for the purpose of placing a spot or curious pattern upon the fabrics, and is adopted in India as well as in Japan. The silk handkerchiefs of thirty years ago were spotted in this manner.

The print producing establishments are then described from "personal observation." For the most part the process combined hand-work and mechanical methods.

The blocks are worked in pairs. One is simply a heavy piece of wood having a perfectly smooth surface, the other a pattern sunk into it called in art mystery "intaglio" which merely means the opposite of cameo. From the deeper portions of the figure, holes are bored to the outer surface through the block, where they are enlarged into funnel-shaped tubes.

To figure the fabric, it is stretched over the plain block with the smooth side upwards. Upon the lower block the figured one is inverted, and the fabric is between the smooth and figured blocks. Pressure is then used sufficient to bring the two surfaces as near each other as possible, and dye is poured down the funnel-shaped holes, and comes, of course, in contact with the fabric wherever the block is engraved. When the fabric is saturated, the blocks are inverted while still in close contact, and the surplus dye is drained off, leaving the pattern on the material. This pressure is sufficient to prevent the "running" of the dyes and the consequent disfigurement of the work. Calico-printing here has an analagous process.

Another process consists in placing a pattern on the cloth by simply stencilling instead of printing. The stencil plates are made of paper that has been rendered non-absorbent by the use of oil or lacquer or other ingredient. There are two methods; by one the pattern is stencilled in the ordinary manner, the dye being used as we do paint; in the other a "resist" is stencilled on the cloth, and the entire fabric is afterwards immersed in the dye-vat, and, of course, takes a uniform colour, except when the "resist" is present. This "resist" may be starch or gum, or any other material that will cover up the surface, so as to prevent the dye from biting.

This "resist" is common in this country for all spotted goods, only we do it by a previous chemical print colourless, but antagonistic to the dye.

But another process adopted is the very opposite of stencilling; in some sort resembling the last. When usually we wish to stencil a leaf in red on a white ground, we cut a hole in the paper to the pattern of the leaf: then dabbing over the paper with red colour, the form required would be created. The Japanese adopt a slower and curious method. The leaf-like pieces of paper above named are taken and placed upon the cloth according to the design, by means of a temporary-adhesive substance, and the entire surface plastered over with a "resist." The pieces of paper are then picked off with a pin, and the fabric is exposed in all parts where these leaves have been placed. When the "resist" is dry, the fabric is dipped, and the leaves acquire the desired colour—say red. Then the "resist" is removed from the cloth by water, and the result is red leaves on a white ground.

To give figures to expensive fabrics is very difficult of description, because we have nothing here to compare it with. The silk, for instance, is given to an artist, and he draws the pattern upon it as carefully as if he were designing an elaborate cartoon. These pieces are about forty feet in length and one foot wide, and upon this entire length the artist will place a repeating or varying design according to the order he has. The pattern is drawn with a preparation of indigo that is removable by washing. He not only makes his outline, but adds depth or shade or any other effect in his design. This is the first stage.

The artist hands the fabric to a workman who has prepared a material most tenacious and ductile—resembling bird-lime—which he has made by boiling the finest rice-flour with lime water of given strength. He slightly warms this glutinous matter, and rubs it on a board with a sort of putty knife, and the stuff reminds the spectator of warm india-rubber—so tenacious it is. A piece of this bird-lime of about the size of a pea is placed on the end of a wooden point or skewer, and a portion of the fabric is stretched flat by bent pieces of cane.

Placing this frame over a small charcoal fire, with his left hand under the fabric to raise any portion at pleasure, he takes the bit of wood that has the mucus ball on its points in his right hand, and touches the fabric at some point of the pattern with it, and it instantly adheres. He then draws it from the surface about a foot, and thus makes a thread of mucus which is so ductile that it could be drawn several yards without breaking. By dexterity of his right hand in using the skewer, and his left hand in raising the cloth where necessary, a thread is continuously formed which is as constantly dropped on the outline of the pattern drawn upon the silk. With consummate skill leaves, flowers, and even stamens of flowers are thus outlined with the mucus that falls upon the fabric like a thread about the size of pin-wire. This outline is not, however, sufficient. Means have to be adopted to thicken it. A conical tube of oiled paper four inches in length with a hole at the broad end of about one inch in diameter is made: at its small end is a tin nozzle, in the apex of which is an opening such as would be made by a darning needle. The tube is then charged with mucus, and through the fine opening in the tin nozzle the plastic matter is pressed in such a manner as to thicken on the outside, also to raise the outline already formed. All this is merely to prevent the dyes to be employed from "running," and the work is ready for the next stage.

Now for the painting. When the spaces enclosed by the little bank are dry, and the mucus is no longer mucus, the artist proceeds to bestow upon this work of painting a care such as if a highly-finished water-colour drawing were being produced. In this way the entire pattern is worked out in all its colours. When the dyes are dry, the colours are exposed for about six minutes to the action of steam in a steam-bath (a sort of kitchen "steamer" placed over a pot of boiling water), and then the mucus matter is removed by the fabric being gently rinsed in a vat of clean water.

If the ground has to be coloured the whole of the pattern is

then painted over with a "resist," and the material is dipped in the dye vat, and the ground unprotected receives its colour.

In many instances these various processes are combined; a part is stencilled and a part wrought in the manner above stated. The work is the most laborious, but nothing can exceed the delicacy of many parts.

Dr Dresser then treats of the loom as used in Japanese brocades, which are not surpassed in beauty by any fabrics in the world. A factory for this production is under a government subsidy to the Mayor of Kiok, and has about twenty looms weaving the richest of tissues. In some of these eight or ten shuttles are employed, each carrying gold or some bright coloured silk. What might be termed their Jacquard apparatus by which figure is given to the fabric, consists of a youth of about seventeen, who, perched on a beam near the ceiling of the weaving shed, gathers up the harness as necessary, and when all is collected, lifts it up, and shouts to the weaver below to throw the shuttle across. This proceeding is gone through between every throw of the shuttle, and is the most laborious manner of producing the exquisite brocades of Japan.

In the same shed with these primitive looms, stands the newest Lyons loom with its perforated cards, and even the newest card-stamping machine; but the work does not produce anything comparable in beauty with that wrought by the more simple native contrivance.

The sundry Art manufactures were next referred to.

At Nara perforated fans, and screws, of silk material are made; and also, some of similar pattern, of paper. The process is chiefly hand-work. Six thicknesses of the material are placed one above another, and through the block the perforations are made with a knife at one time, by hand, however fine or intricate the pattern; and no more than six thicknesses are cut at one time.

The metal worker is then discusssed, and the Japanese kettle as a specimen. It is of pleasing form and covered with conical protusions, that have a geometrical arrangement. These eminences are an ingenious design to increase the heating surface and are very numerous; they are so accurately disposed that it is difficult to detect the slightest displacement of any one dot, and yet all is the result of hand labour. A hollow mould which is to give form to the outer surface of the kettle is made of sand, and is notwithstanding perfectly smooth, and is shaped on a block of wood of the required form. The mould maker then takes a small bar of iron of about three inches in length, having an end exactly the form of the eminences he wishes to have on the side of the kettle, with it he makes depressions in the mould, which hitherto has been still smooth. These depressions are deep or shallow as he wishes, and are placed according to his skill by the guidance of his eye, and of course when the pot is cast they become eminences. He has no measuring instruments whatever.

Japanese bronzes, and even iron pots having flowers, birds, or even a dragon in almost full relief upon them, are not uncommon to the observer acquainted with Japanese productions. The casting of such objects would be accomplished here by "piece moulds," and is a very expensive process; but the Japanese will cast a chrysanthemum with its numerous juxtaposed petals, as perfectly as a more simple ornament, and such a casting no piece mould could enable us to produce. This is the method. Whatever is to be cast is modelled in wax; if a flower is to protrude in almost full relief from the sides of a pot, it is first modelled in wax. Then it is attached to a wooden block of simple form, such as would, if the wax flower were not attached to it, drop from the sand if they were used for the formation of a mould.

The model, consisting partly of wood and partly of wax, is carefully brushed over with a pulp formed of sandy clay; and, when dry, receives a second coating that contains more sand: this is sometimes followed by a third and a fourth. When these are dry, sand is piled around the mass, and pressed into the interstices between the parts, which interstices have, however, been largely filled by a previous application of semi-fluid matter. When sufficient sand has been pressed around the model to form a solid mould, the mass is taken to a kiln or muffle—an oven-shaped vessel used by refiners—and is there exposed to a degree of heat sufficient to melt out all the wax, or rather mixture of wax and resin, which is first absorbed by the sand, and then dissipated from the mould as gas. These moulds are warmed before the casting is made, so that the metal may not be chilled while running along the smaller channels. If a thousand vases had to be cast, each with a flower in relief on the side, and if each vase was to be precisely of the same pattern, a separate model would have to be prepared for the casting of each, and the same labour expended, as on the production of the first.

Dr. Dresser finally spoke of the lacquer manufacture of Japan, which is accounted the choicest of their art manufactures. Here it does not appear that we have any "personal observations," but sundry trade announcements as to companies and the like now being formed to expand its sale in this country, the continent, and America. We therefore omit any reference to the extended description of its manufacturing processes since the authorities are numerous and many, and the subject of sufficient interest to form a separate paper.

Notwithstanding the observations made in the course of this review and extract, the public will thank the well-known art-designer for the industry and enthusiasm which has enabled him to give us many facts and descriptions not before possessed, and the announcement that he is partially pledged to add to the list of valuable books on Japan by an extended compilation and the entire contents of his note book on his visit to that singularly interesting and extraordinary community. The collection of Messrs. Jackson & Graham, in Oxford Street, is in itself an amazing illustration of their incomparable ingenuity, and that collection is always open to the public.

RAILWAY CARRIAGE WHEELS MADE OF PAPER.

SIX hundred patents for wheels have been taken out in this country alone, and in America many. We are now asked to look at an old friend from that land of "novelty" who claims to make these useful parts of paper material. The idea is not new there, notwithstanding what may be said to the contrary. It is now ten years since, at least, that compressed paper has been tested for this purpose, and in the early days of Pullman's cars such wheels were adopted as an experiment. They were not continued, but have been used elsewhere through the States, and with average success. We must in offering a description preface a remark somewhat less sanguine than the promoters express—we do not think that iron will be displaced. At the same time a general description may excite some little notice or give pleasure.

As now manufactured the wheel may be said to consist of three parts: a cast-iron hub, or brake, a steel tire, and compressed paper or filling. Thick paper boards are used, which have been made thick by repeated layers under hydraulic pressure in the usual way. Every thickness—which is of several inches—has to undergo a process of drying, and the entire wheel padding takes about fifty days to prepare a single block. These are then turned in a lathe and fitted exactly to the tire and brake, and then all goes under hydraulic pressure. This paper-block is then enclosed between quarter-inch wrought-iron plates held by two circles of bolts, one passing through the flange of the tube, and the other through a web inside the tire that secures all the parts together. These bolts are turned and accurately fitted. The web on the tire through which the parts are bolted is ¾ in. in thickness and 2½ in. in depth. It is intended to strengthen the wire and, by a peculiarity in its fastening, to prevent the tire leaving the wheel in case of fracture. The bolt hole through the web is longer and the side plates of less diameter than the inner circumference of the tire, and hence there is no direct metallic connection between the tire and the brake. This method is to enable the paper block to neutralise concussion and prevent crystallization of the axle by making the wheel run easier on the rails, and, by diminishing the noise, make them especially useful for sleeping and drawing-room carriages. The manufactory is at Hudson, New York. There is no question about the scheme being ingenious, but the result may not be so rich as the expectation. It is the reproduction of a very old idea, and is, of course, aided by modern experience: still iron and steel have a clear advantage that is not likely to be overcome.

GALLIUM—A METALLURGIC DISCOVERY.

PROFESSOR ODLING delivered a lecture at the Royal Institution the other day upon the above subject, which has caused some sensation from the high position of the lecturer and the importance of his theme. After stating that there are sixty-four kinds of matter which chemists have not succeeded in decomposing, but which they can trace undecomposed, he classed them into metals, half-metals, and non-metallics; the first are the most numerous, and the others have a puzzling

property of mingling one into another. Of the non-metals, bromine is the latest known, but that has had a life of fifty years, having been discovered in 1826 by M. Balard, a distinguished French chemist. During the last twenty years five new metallic elements have been discovered, and there is some evidence of a sixth being likely to add its claim. The last of the five, however, is gallium, detected by M. Lecog de Boisbaudran, in 1875, and named by him in honour of his country. It was discovered by the process of spectrum analysis applied especially by him who is eminent as a spectroscopist. The spectrum of gallium is characterised by two marked violet lines, the less refrangible being the most brilliant. In the early investigation this metallurgist could only obtain a dozen grains from half-a-ton of zinc-blende, taken from Pierrefite in the Pyrenees, but with these he established the leading properties of the element.

In its appearance gallium has a general resemblance to lead; it is not so blue, or so soft, but it is malleable, flexible, and can be cut with a knife. It is not an easy volatile metal like zinc: but it is unlike lead in that it acquires only a very slight tarnish on being exposed to moist air, and is easily calcined at red heat. Its specific gravity is a little under 6, whereas aluminum is 2·6, zinc 7·1, and lead 11·4, and it has a most remarkable property in its low melting point. It liquefies completely at 86° F., that is, below the heat of the hand: and, still more curiously, when once melted at this temperature it can be cooled to the freezing point of water without solidifying; and it may be kept unchanged in a liquid state for months. M. Boisbaudran described it in his first communication to the French Academy as a new liquid metal similar to mercury; but on touching with a fragment of solid gallium a portion of that in a liquid state it at once solidifies. It does not resemble lead also, in that it is a highly crystalline metal, its form being that of a square octahedron. In its chemical habitudes gallium that is so rare has the greatest analogy to the abundant element aluminum. In particular, it forms a sort of alum that cannot be distinguished from ordinary alum in appearance, but it contains oxide of gallium instead of oxide of aluminum or alumina.

The history of its discovery gives to gallium its chief scientific interest. Previous elements have been discovered accidentally, and their uses have been unforeseen: they were, in fact, surprises. Boisbaudran took up the zinc-blende, expecting to find a new element, from having, in the course of his spectral studies, been led thereto by speculation. The existence of such an element was predicted very positively by M. Mendelejeff, a Russian chemist, in 1871, and in a cruder form many years previously by Mr. Newlands, an English chemist. This double prediction was based on a study of the relations of known atomic numbers of the elements. These have only lately been perceived to be almost a series associated with a sereation in properties of the elements themselves. In the numerical series, however, certain terms are missing, and particularly one between aluminum and iridium. Mendelijeff predicted what these properties would be: viz.:—that the specific gravity would be about 5·9; and Boisbaudran first found in his small tests that gallium was 4·7; but on repeating his labours on a larger scale in 1876 he found it to be exactly 5·935—a most remarkable fulfilment of the speculations of the Russian chemist.

AUTOMATIC GAS-LIGHTING.

PROVINCIAL towns are more likely than the Metropolitan districts to have recourse to this method of igniting the public lamps, because the ground to be traversed is not disturbed by irregularities, is of limited area, and in every respect manageable. Mr. St. George Lane Fox, of Cromwell Place, London, has rendered public service in describing the means and the method which modern science prescribes for lighting and extinguishing street lights.

The means employed centre in electricity. They may be direct or indirect, but in every form electricity is the medium. When the matter was first taken up some years ago, and it was known that an electric spark, or a fine platinum wire that was rendered incandescent by the electric current, would ignite a stream of gas, it was thought that there would be no difficulty in applying that agent to the lighting of street-lamps; and experiments were made in large buildings for effecting that object by means of insulated wires.

The Assembly Rooms at Paris and South Kensington are lit by this system, the gas being turned on and off at the main. The advantage is obvious, for such vast areas are all but inaccessible to lamplighters; but the application of that method to great distances became a most difficult problem. When it was attempted to convey the high tension current to a great distance how could the wires be insulated?

It was not desirable to light every gas burner, and if the limit happened to be one, two, or three, the expense question settled the matter. Moreover, the early methods had no provision for turning the gas on and off automatically, and therefore lamplighting by electricity had to be laid aside, as also several other suggestions of the like nature.

Professor Tyndall took the chair at a meeting of the Society of Arts convened to hear Mr. St. George Lane Fox describe his invention, which is about to be put in force in Pall Mall and Piccadilly, and his address we abridge. He ignites gas at considerable distances and at numerous points by supplying each lamp with a small induction coil, so that the primary wires of each one of them forms part of a circuit without a break in the metallic continuity. Many difficulties arose, but at last an apparatus was constructed for accumulating the electric current and stirring it into a reservoir or condenser made of glass plates and tinfoil laid side by side alternately. The condenser is not charged direct by the battery, but the current is made to work this Rhumkorff induction coil, from which is derived a current having an enormously increased electromotive force, and that electricity is stored in the condenser.

When charged the whole of the electricity is sent through the line and produces the extraordinary results. The process of turning the gas on and off is simple. There is a soft iron core running through the centre of the coil to produce a reciprocating horizontal motion of a permanent horse-shoe magnet suspended on needle points just above the coil.

"The soft iron core with the primary coil is in fact an electromagnet, which can be magnetised so as to render its poles reversible at pleasure; the magnets are carried in a small metal frame, having a passage through it for the gas to pass to the burner at the top, and being provided with a stopcock, or valve, which is actuated by the reciprocating magnet. The whole of this apparatus is enclosed in an air-tight metallic case, which measures about 2½ in. high by 2½ wide, and is screwed on to the supply pipe in the lamp; the insulated conductor or line wire being carried down the interior of the lamp-post and laid under ground, except, of course, where an overhead line is admissible. The turning of the gas on and off is accomplished by opening and closing what may be termed an electric needle-tap. The plug of this needle-tap is cylindrical, and about a quarter of an inch in diameter, and is carried in a socket, which it fits rather loosely. It is made to turn in this socket by the action of the reciprocating magnet, a couple of studs on which are brought into contact with a small pin or lever connected with the plug, and forming, in fact, the handle of the stop-cock. The annular space between the plug and the socket (which is about one-thousandth part of an inch) is filled with some liquid, which is retained by capillary attraction between the two surfaces, the joint being thus rendered perfectly gas-tight. The oil of bitter almonds or glycerine are both well adapted for the purpose, on account of their non-oxidisable character, and from the power they possess of resisting the action of very low temperatures. It will be seen that a special feature in the apparatus is the introduction of a fixed core, which can be magnetised, so as to render its poles reversible at pleasure, and in conjunction with it a movable magnet, the polarity of which is permanent. An electric current sent either forwards or backwards for a few seconds, will turn the gas on or off in every lamp in the circuit according to the direction of the current."

Mr. Fox then described the method proposed for putting the system into practical operation:—"There would be for any district of say two or three thousand lamps a central station, from which the wires would proceed in every direction, so as to command a number of distinct circuits; all that is necessary to have at the central station would be a battery of some sort, or a magneto-inductor, that is, a machine for producing an electric current by mechanical means. As no solutions are used for generating the current, there will be none to replace, and it is always ready for use, so that by turning a handle a powerful current is produced. I believe that these machines have been adopted very largely on the German railways, for releasing clockwork used in signalling, or wherever a rather powerful current is required for a very short length of time. When I say powerful, I mean as compared with the ordinary telegraph currents, which are sometimes not more than the thousandth part of a veber. By means of a switch and a commutator, the electric current from this machine can be directed so as to operate separately on each one of the circuits, and by this means turn the gas on or off. Let us suppose the gas turned on, the next process is of course to light it, this is effected as I have said by sending a discharge from the condenser. A con-

denser such as I have here would, I believe, have a sufficient capacity for lighting about a hundred lamps. It is extremely simple in construction. It is constructed of alternate metallic plates, with an insulator or dielectric between them; the conducting surfaces in this case are of tinfoil, and the dielectric of crown glass. A number of plates are used so as to get a large surface in a small space. The simplest form of condenser is that known as the detonating plane, and consists simply of two sheets of tinfoil, pasted on opposite sides of a glass pipe. The coil used for charging the condenser need not give more than about three-quarters of an inch spark in the air. The discharge, like the current, will of course have to be sent through each circuit separately, and this is also done by means of the switch arrangement. The chief objection that has been raised to any system of lighting street lamps by electricity, is that the conducting wires would be liable to be cut, and so interrupt the continuity of the line. But I am sure that this is only an imaginary difficulty, as it would be a very simple matter to discover the place of rupture, and patch it up temporarily, almost as quickly as it would take to light a single lamp by the present process. For instance, a double earth could be made at the point of rupture so as to divide the circuit into two; besides which it is extremely improbable that more than one circuit would be out of order at the same moment, and just at the time of lighting or extinguishing. I have here a sample of an underground cable specially prepared for me by Messrs. Siemens, Bros.; it consists of a core composed of one solid copper wire insulated with two layers of gutta percha served with tarred jute, and sheathed with 14 B.B. galvanised iron wires, then served with one layer of tarred jute yarn and two coatings of compound; the diameter of this cable is about half an inch. It will of course be laid in the ground without any additional protection, being in itself very strong and durable. Cables very similar to this one in construction have been very extensively laid in Germany for the underground telegraph lines. I am, however, of opinion that an overhead line well out of reach, that is to say, about 16 ft. from the ground, and supported as they are now in Pall Mall, would answer well for any small districts where it would be thought too expensive to lay an underground cable."

THE CONSTRUCTION OF LIGHTNING-RODS.

FOREIGN climes afford illustrations in regard of lightning rods that cannot be obtained at home. It is not for the first time that notice is taken by us of Dr. Mann's remarks, and now it is a pleasure to reproduce by abridgment his directions and opinions on a subject that is indeed of serious import here, but is of infinite interest all over the world,—the lightning-rod.

Nature is the teacher of science in this particular case. Her phenomena supplies the only data that can come to profit in any question depending on electric affairs. The man of science may deal with the effects he produces in the laboratory or the study, but he cannot direct the course of the lightning, or reduce it to ordinary control. He will be obliged to watch for opportunities and to wait for events if he desires to interpret the secrets of electric action that is exposed by thunder and lightning.

An accident occurred in 1875 at Barrackpore that gave materials for observation and improvement. A two storeyed barrack was slightly injured by lightning. The central portion was higher than the rest, and surrounded on three sides by verandahs much lower. On each side of the higher building were fixed lightning conductors, having the tapering iron rod of 1½ in. diameter, and carried up to 5 ft. above the parapet. This rod led downward to a bit of iron water-pipe of 5 in. diameter that was connected with a similar one and ran down the outside wall of the verandah by a 4 in. by ⅛ band of iron that was carried across the flat roof of the verandah compartment, which was made of cement. The down pipe of the verandah was connected at the earth with a piece of pipe inserted into the ground some 18 in., having links and chains.

The thunder-storm occurred, and by-and-bye one peal louder than the rest brought a flash of lightning that struck the iron bar which crossed the roof of the verandah, and passed through the masonry to the girder underneath and chipped a bit out. Seeing that this was all the mischief done the question arose,—why the lightning-rod had been avoided by the current, and why the bar—so much lower—should have been struck instead.

Experiments were instantly made on a Wheatstone's bridge, and the cause was directly revealed. From that course of experiments was manifested the folly of employing common metallic structures, and parts of a building, for the purposes of protection, unless the uttermost care is taken that the joints are perfect and continuity sure. A lightning-rod is not safe if it have joints; and they must be tested as to their capability of resisting electric currents: otherwise nothing is certain. If on test a break is evident, repair can be instantaneous: if no test is made, an accident will soon proclaim the folly of neglect.

This case shows that a lightning-rod with a bad earth-contact effected through a chain, but with a good resistance, gave efficient protection. The conductor was forcibly struck, but conducted harmlessly to the ground, leaving no trace of damage in its course. Another consideration arises out of this case. Faulty lightning-rods are a source of danger. Had a soldier been upon the verandah he would have been killed by the jump of the lightning on its way to the girder and water-pipe, and on the other hand had there been no pipe or earth his chances of safety would have been small. But if the conductor were efficient from point to earth—good points above, and jointless communication through a perfect rod, with a free earth-contact instead of dangerous chains—he would have been safe. The conductor must be safely arranged. We must be very careful in all these investigations not to be seduced into doubting that the lightning-rod is a positive attracter.

Dr. Mann refers to another case of injury from lightning at Natal. The house of a Dutch farmer happened to be in a place famous for thunder-storms, and upon a ridge having a high mountain on the north-east. A little stream ran from the lower slopes of the hills, and divided close to each end of the building—a one storeyed structure with an iron roof—having a chimney at the east end and three windows and a door in the south front. This house was struck by lightning, although it had two lightning conductors, and the lady of the house was killed, having marks of burning along the skin of the neck, spine, and lower parts: her boots were ripped, her children hurt, and a large brass pan hanging on the door battered on one side.

How is such a case to be met? The place was examined and the affair explained. The house had a galvanized roof with wire-rope conductors of ½ in. diameter at either end—*both broken off some time ago, half-way down, and the lower half gone.* The lightning could not do otherwise than what it did. It struck the conductor, passed along the galvanised roof, and leaped through the window to the earth, shattering the one and killing the other. She was the earth-terminal of the faulty conductors. Galvanised roofs are dangerous even with two conductors, but the danger is increased by extended terminal rods. Under any circumstances the iron roof is an imperfect conductor without earth connection.

Another African case is noticed. A storm came from the river and crossed the high road to the settlement at the foot of a hill; and, as it passed, killed sixteen natives and five oxen by one flash of lightning. The lightning is a broad discharge, and one that destroys not only life but grass and trees by a blow and not by an electric communication.

Mr. Pidgeon, of Paignton, near Torquay, resided with his family at a house placed on a bold headland projecting into Torbay. At some former time a flag-staff had been erected by the coast guard just before the house; it was a 50-foot mast with a metal vane, but without a lightning-rod. Half-way was a stay of four galvanised iron guy ropes that ended at a foot from the earth in half-inch iron chains, that had been so much corroded that the iron was only ⅛ in. diameter, but were anchored in a very dry red sandstone conglomerate. A heavy scud drift set in from the sea as the family came up from the shore. Two had just taken shelter from the hail-storm near the door about ten feet from the chains spoken of, and the owner was standing twenty feet off, at about ten feet from another of the chains, looking at the drifting scud as it came from the sea, when a flash of lightning struck the flag-staff, splintered the upper portion from the vane to the guy rope fastenings. At the instant all three were struck, but neither were aware of any flash, or knew of the falling mast. One thought she was fired at, and the others that a blow unknown had been struck. There was no consciousness of lightning until on their recovery the evidence was seen in the broken mast. The radiating lines on the skin of the lady corresponding with the position of the door-bolt against which she was leaning also proved that lightning was the cause.

Where the chains entered the path little craters were formed, and the soil was loosened to the depth of twelve inches. Around the base of the path shallow trenches were opened, one of which ran about thirty feet, to an iron roller and a little further. Three of the chains were broken, twenty of the links being snapped, but curiously not where corrosion had occurred. The fractures were bright and crystallized showing no trace of heat or fusion.

We see here the effect of a bad earth-contact. The lightning

bursts and spreads itself in all directions through the resisting substance and breaks it. The individuals were saved by this diffusion.

Professor Melsens has for a long time advocated the system of employing numerous rods of small size, rather than one rod of large size, in establishing a protection from lightning. He virtually aims at covering the building which is to be protected by a sort of metallic net, thrown broad-cast over the structure and furnished with numerous points projecting into the air above, and with numerous earth-contacts, or rootlets, diving down into the soil beneath. He contends that the usually accepted view, that a well appointed conductor protects a conical space, the diameter of whose base is twice the height of the conductor, is not worthy of implicit trust, that numerous accidents have in reality occurred within that limit, and that the only absolute protection that can be devised is the plan of covering the entire structure with intermeshed lines of defence. At the time of his visit to Brussels, the Professor had in his laboratory two little birds whose sphere of duty it was to demonstrate the absolute reliability of the network plan. One of the birds in performing this task was placed in a special cage of netted metallic wire, and successive shocks from a battery of fifteen large Leyden jars were then flashed through the cage without any injurious effect upon the inmate. The feathered experimentalist went through this ordeal for my enlightenment with the utmost *sang froid*, as if he had quite realised the soundness of the doctrine that was illustrated by the play of the mimic lightning about his head.

Professor Melsens' views have been elaborately carried into effect at the Hotel de Ville, at Brussels, and it is hardly too much to say that this noble building is in all probability one of the most perfectly protected structures in the world, so far as possible accident from lightning is concerned. The hotel consists of a principal building in front, surmounted by a pinnacled turret and spire, 90 metres, or 297 feet high, and carrying upon its summit a gilt statue of Saint Michael flourishing a drawn sword, and standing upon Satan, represented in the form of a horned dragon turned upon its back. There are four galleries ornamented with corner pinnacles upon this spire, and the main block of building beneath has also six spire-crowned subordinate turrets, and three parapetted gables, projecting above the roof. Behind the main block of building there is a square enclosure, or inner court yard, formed by an addition running out from the front block, so as to constitute the three other sides required to complete the quadrangular inner court.

The upper terminal of this system of conductors commences in the metallic statue of the saint, which is fixed upon a strong central pivot of iron imbedded in the masonry beneath, and which serves the purpose of a weathercock. The point of the sword of the saint, which is no longer needed for the strife with the prostrate enemy of man, is raised to heaven, and acts as the first recipient of the lightning from an approaching cloud. But the sword is not left alone in the performance of this office. The platform on which the saint stands is the summit of a kind of cupola, covered with copper and lead, and around this is placed a group of eight vertical iron rods, which radiate above into a perfect forest of tufted points, or aigrettes. Each rod is itself tufted, and from a short distance below sends out a divergent spike ; so that the metallic platform, beneath the feet of the statue, is guarded with a coronet of 48 points, distributed in a circle 16 feet in diameter, and bristling around in all directions.

The eight iron rods which terminate in this coronet of points, and in the metallic statue above, are each 10 millimetres, or about two-fifths of an inch in diameter, and together make up a section of 628 square millimetres, or a trifle more than one square inch. Each of these rods has a continuous and unbroken length of 100 metres, or 310 feet ; and the eight rods, under all the circumstances of the construction, collectively furnish nearly half as much facility again for electrical conduction as the limit of safety named in the standard instructions of the Academy of Sciences at Paris.

The eight main conductors descend along the octagonal faces of the tower, and then along the slope of the roof and the wall of the building, into the interior of the court-yard. As they do this, however, they gather up other strands of similar character and size, which come to them from the ridges and parapets of the quadrangular extension of the building, and from the subordinate turrets and gables. Tufts of points, or aigrettes, project upwards from these horizontal stretches of the conductor, as well as from the summits of the lower tower, in great abundance. Altogether there are thus 426 points, distributed in 60 aigrettes, and lying in 10 different planes, provided as air terminals for the protection of this building. Of these 385 are of copper, 63 are of galvanised iron, and 8 are spikes gilded at the end. From one of the higher galleries of the tower the eye looks down upon a perfect *chevaux de frise* of spikes bristling up from the building into the air, in all directions.

In alluding to the plan which is now so commonly advocated, of enlisting the mains of gas service in towns to do duty as earth connections for lightning-rods, it may now be necessary to say, in the way of caution, that no iron gas-pipe smaller than an inch should ever be allowed to approach to any part of a system of lightning defence, and that no gas-pipe of soft metal of any kind should be permitted to be near to the conductor. It must be well kept in mind that the very circumstance which makes the gas main so good an earth-contact for a conductor, constitutes at the same time a grave danger if this precaution is not observed. The mains of the gas service are generally so ample and excellent in the earth connections which they supply, that lightning striking a conductor with an ordinary earth-plate, or probably with some earth connection even less carefully provided than that, would be almost certain to leap across to any soft metal gas-pipe placed near to the conductor, in order to avail itself of that better and easier path to the earth ; and, in doing so, would melt the soft metal, and set light to the gas. Fires are very frequently caused in this way. It is a radical axiom of lightning protection that the conductor must never be carried near to small, and especially to soft metal, gas-pipes.

This is the form of a condensed abstract of the conditions that may be most advantageously observed in the construction of lightning-rods.

1. The copper rope, or rod, employed as the main stem of a lightning conductor, should in no case have a diameter of less than four-tenths of an inch.

2. A rope, or rod, of four-tenths of an inch in diameter is not large enough for the protection of buildings that are more than 80 feet high. The resistance offered by a conductor of any given diameter increases with its length. Long conductors, therefore, require to be of larger size than short ones.

3. For every additional 80 ft. of height, or of extent, a second rope, or rod, of the same transverse dimensions must be added, or the sectional area of the single rod must be increased in a similar degree.

4. It is of no practical importance whether the conductor possesses the form of a rope of twisted wire, or of a rod, provided it be of sufficient dimensions for the work which it has to perform.

5. If a cylinder, or pipe, is used instead of a rope, or rod, it must be considered as furnishing the same conducting capacity that it would have if slit up along one side and opened out into the form of a flat band.

6. Galvanised iron may be used as a conductor instead of copper, but it must have considerably larger size, because iron is of inferior conducting capacity to copper. Increased size can quite compensate for inferior transmitting capacity.

7. An iron rope, or rod, to be equally efficient, must be rather more than double the width of a copper rope, or rod. In exact figures the proportional diameters needed is as 6·7 to 2·5. The conducting capacity of iron is five and a half-times less than that of copper, or, in more exact figures, as 14 to 77.

8. A galvanised iron rope conductor should, in no circumstance, be less than eight-tenths of an inch in diameter.

9. When a strip, or tape, of copper is used in place of a rope, or rod, it should be in no case less than three-quarters of an inch broad, and one-eighth of an inch thick. Such a strip contains a sectional area of a tenth of a square inch.

10. Galvanised iron, when used in the form of a strip, should be four inches wide and an eighth of an inch thick. Such a strip would contain a trifle more than half a square inch of sectional area.

11. A lightning-rod must be absolutely unbroken, or of continuous length from end to end.

12. When metallic water-pipes, or other similar stretches of metal, forming part of the structure of an edifice, are made to do service as lightning conductors, all joints must be carefully made good by solder, and tested afterwards to ascertain the sufficiency of their conducting capacity. Without this precaution, the arrangement is liable to be a source of danger, instead of a means of safety.

13. It is quite unimportant how a lightning-rod is attached to a building. It does not need insulating fastenings ; ordinary metal clamps of any kind may be quite safely employed, provided the rod be of good conducting capacity, and otherwise efficient.

14. The rod must be terminated above in metal points, well projected up into the air.

15. The terminal points may be made either of copper, or iron, but they must be tapered out very gradually, and be perfectly sharp. An alloy composed of 835 parts of silver, and 165 parts of copper, forms an excellent material for tipping the points, because it enables these to preserve, for a long time,

their sharpness under the circumstance of exposure to moist air. The silver tips should be made about two inches long, and be firmly screwed into the termination of the conductor.

16. The air-terminal of the conductor should be branched out into several points. Multiple points—or aigrettes, as they are termed—of this kind, are now made in copper, of very good form, by all the best electrical engineers.

17. The larger the building that has to be protected, the more points, or clusters of points, should be used. In the case of buildings of any considerable extent the conductor itself must be branched out to all parts, and each branch must end in its own projecting tuft of points.

18. Terminal points should project into the air, at least eight feet beyond the building itself.

19. The general idea may be kept in mind that lightning conductors approximately protect a conical space around them, whose base is four times as wide as the conductor is high. This principle, however, is not an infallible one, and it must not, therefore, be too implicitly relied upon. Whenever any parts of a building approach towards the limiting surface of such a conical space, additional points should be fixed there, and be brought into connection with the general system of the conductor.

20. The bottom of the conductor must be carried down into the earth, and be connected with it by a surface-contact of large extent.

21. About the best earth-terminal that can be contrived, consists in connecting the end of the conductor with the iron main of a gas-service, or water-service. The end of the conductor should be attached to a broad piece of copper or iron, and this should be laid close along the metal surface of the main underground, or, where practicable, be even attached to it by some kind of solder.

22. Where there is not the opportunity for adopting this expedient, the lower end of the conductor should be placed in a shallow trench, opened out twenty feet in the moist ground, and be carried along in it to the end, and be also well packed round with gas coke, broken into small pieces, before the trench is covered up with earth.

23. Plates of copper, or iron, may be used as earth-terminals, if this be preferred. The plate should not then, however, in any case, furnish less than two square yards of earth-contact, reckoning both sides, and it must be carefully rivetted and soldered to the conductor, and be surrounded with broken coke, before it is buried up in the earth.

24. When the earth is unavoidably dry, the earth-contacts of the conductor must be made proportionally large. Abundant size may be so managed as to compensate for the disadvantage of dryness.

25. With dry earth-contacts, lightning-rods may be a source of danger instead of safety, if this precaution be not observed. The only means by which it can be ascertained whether a dry earth-contact has been made large enough is the employment of the galvanometer. This test should never be omitted when the conductor terminates in a dry soil.

26. The danger of a lateral discharge from a lightning conductor diminishes with its capacity. A large well-pointed and well-grounded conductor will convey a very powerful discharge to the earth without the slightest tendency to strike through any object external to the rod. A small and imperfectly appointed conductor, on the other hand, is always prone, during the transmission of lightning, to flash off some portion to surrounding objects.

27. The capacity of a conductor may practically be increased in three ways to ensure this efficiency and safety :—1. By the employment of larger ropes or rods ; 2. By a more abundant service of points ; and 3. By amplification and improvement of the earth-contact.

28. The proof that a conductor has been made capacious enough by the judicious employment of these means is furnished by the magnetic needle of a galvanometer not being materially deflected when a galvanic current is passed through the conductor to the earth.

29. All large masses of metal contained in a building should be metallically connected with the lightning-rod, unless when such are liable to be occupied by living people during a thunderstorm, as in the case of an iron balcony fixed outside a wall in front of a casement ; it is then better that such masses should not be connected with the conductor, because, under such circumstances, persons standing upon them would be in less danger of being struck. When they are connected with the conductor there is always some risk of persons standing upon them furnishing a path for the lightning to the conductor.

30. The best method of connecting masses of metal with a conductor is by closed circuits. That is, a connecting metallic band should proceed to them from two different parts of the conductor.

31. Soft metal gas-pipes must never be allowed to run anywhere near to a lightning conductor, because there is always danger when they are so placed of some part of the discharge deviating from its proper route to avail itself of the good earth-contact furnished by the expanded mains of the gas supply, and in doing so of melting the small fusible gas-pipe and setting fire to the gas.

32. Zinc or iron pipes on the tops of chimneys are always to be regarded as masses of metal that are to be brought into connection with the conductor.

33. Lofty chimney shafts may always be satisfactorily protected by a single conductor. Care must, however, be taken that the size of the conductor is adequate for the height, and the top of the shaft must be entirely encompassed by a bar or parapet edge of metal, and points must radiate from it on all sides into the air.

34. In the case of manufactories where corrosive vapours are emitted from the chimneys, copper or iron terminals should be soldered into leaden tubes, and a subordinate service of points should be added at some lower level, where they would not be liable to be affected by the corrosive vapours.

TRACTION ON TRAMWAYS.

MECHANICAL traction on tramways has become a subject of intense practical interest since the universal applicability of such locomotion has received public acknowledgment. Our data extends over half a century, but it is of the most scattered, crude, and for the most part untrustworthy character : nor does the experience of the railway afford much instruction, and, indeed, as Mr. Haddan ably characterised it, on the contrary, "it is not only inapplicable, but misleading." He proceeded to lay down a hard-and-fast line to which it is not possible that we can subscribe, namely, that "It is imperative in this novel branch of engineering science that the conditions to be imposed upon the machine and system generally shall be clearly set forth, leaving to manufacturers the obligation to meet them in the most economical manner."

He then lays upon certain portions of the public the duty of imposing those conditions. These are—1, The Board of Trade ; 2, The Civil Engineer ; 3, The Locomotive Superintendents ; 4, The Traffic Manager ; and 5, The Public.

Now the public has long made up its mind, that although usually, as in this little list, the last mentioned, it will not be a party to imposing conditions. It cannot in the first place, being hedged about by law, or custom, or sentiment, and it will not take responsibilities involving action, simply because such responsibilities are usually merely tentative experiments, and mysteriously costly. They curb the public with officialism or they deceive in their results.

With this protest against anything approaching arrogance, it is candid to give the essence of the suggestions or directions that follow, premising that the tone adopted is one of attack on manufacturers for imposing highly extravagant and unnecessary conditions on the construction of the road, and even on the general policy of the system. The reply is obvious. Go to the best known manufacturers and see their contracts, or the best companies and see theirs. The five classes who are charged with the duty of "imposing conditions" would instantly—one and all—repudiate and deny both the charge and its justification. The mechanic, the engineer, the manufacturer, and the public, have a common interest, although pursued by various methods, and we do not live in times when attacks on common interest can be made with impunity, for derision creates prejudice, and that brings insufferable conceit into natures that are better kept free thereof. However, here is the dogma.

"Every engineer now accepts that the following theories, although they will work, are anything but commercially sound, and should be abandoned when possible, viz. : that—1, Dead weight is a necessary power (adhesive) on a rising gradient. 2, Dead weight is a necessary power (brake) on a falling gradient."

If theories will work, there is *prima facie* evidence of a considerable element of truth in their nature ; and the question of commercial soundness may be left to find its own level. Certainly a working theory is not one to be hastily abandoned. Leaping to conclusions, we read, "If therefore, on the moderate grades of a railway made artificially to meet these conditions, the main principles of railway traction are to be regretted, how much more so will it be if such principles influence tramway action where grades are steeper and unalterable. The engine manufacturer, therefore, is not the proper person to be entrusted

with these interests. As tradesmen they can advocate what suits their plant, which condition the civil engineer far too often accepts as a necessity, but it is what has done much to ruin export trade and the employment of English civil engineers abroad, because the conditions required in each case are rarely imposed by one or met by the other."

Now again a protest must be made. A mechanical engineer has sense enough to know better than despise his "civil" brother, and the civil engineer should not indulge in imputations in any case. His assumed position is that of a profession, and although he may treat his indispensable co-labourer as a "tradesman"—whatever that may be in the case of a producer—it is not becoming a gentleman to be casting dirt about the world. That is not practical wisdom. The civil engineer has no doubt some liability to have recourse to means that are not of the loftiest morality, but he need not say that what he terms Trade Catalogues—*i. e.* Manufacturers' Lists—are the text books of some of his order. He proves too much when making a supreme profession subordinate to what he would portray as an inferior.

The experience of Paris is adduced by Mr. Haddon as illustrative of the necessity existing in cities for the employment of tram communication. Underground and overhead are both distasteful to the French metropolis, because of the interference with architecture, deservedly appreciated, or with elaborate drainage, such as no other city can boast. Allusion is then made to relieving London Bridge by forcing the traffic over Southwark Bridge, but that betokens an ignorance of metropolitan matters that need not be referred to further.

Having thus far gone—perhaps out of our way—to check the tone and tendency adopted, we will state the rules or proposals for guiding the five bodies upon whom this gentleman would affix responsibility, and offer suggestions with all deference at the end.

1. *The Board of Trade.*—The officers to have clearly defined executive powers. Each Company using steam must furnish monthly returns of the performance of the engines, and the consumption of oil, fuel, etc.: and all other data that can aid future legislation. The steam tramway traffic to be worked in opposite direction to ordinary traffic, if a double line, not otherwise, because then it must be half-and-half. This rule would prevent vehicles being run into from behind. In narrow streets no car shall stop to take up or set down: and on wider streets passengers may take up only at certain points, but may stop anywhere to put down (because, forsooth, that through passengers wanted to get on; but, he would suggest, perhaps the sitters wished for their destination). "In collisions, the public vehicle is responsible, except on cross roads." (So much the better for private coachmen!)

Any waggon that breaks down and obstructs the tram is to be responsible if it could have avoided the interruption of the tram. (What if the tram had nothing to do with the waggon?)

Stop speed at all crossings, and increase the number of stopping stations. At cross traffic where there is no station the police must take charge, with advertised notice to the public; and all the speed is to be defined by time-table.

Limit wheel diameters to two feet, for you cannot trust mechanical control, it is sure to be tampered with. Fire-boxes to be regulated: super-heating may be allowed under provisional arrangements, but no smoke or steam to be visible.

Gauge-glass clocks must be self-closing to arrest steam exit. The engine-fenders must be perfect, despite wear of brasses and wheels. No points shall be moved by unlockable needles, and if the weight of load exceed that of the engine a special brakesman must be engaged. If an engine breaks down there shall be five minutes grace for clearing. (Who is to provide it? eh!)

No machine must be unattended, and the servants' names must be written as a guarantee for its safe guidance.

And none shall be by one man driven if atmospheric changes exceed three, or the fire is weak, or the boiler weak, or anything that disturbs the driver. (Is not that a peculiar wisdom?)

And the running front of projecting lights shall not allow a light to be shown save the blaze of the engine.

You must not allow an engine or car to be without attendants nominally described.

When the line is laid the blocks must define the right of way.

[We have no words to express or describe the waste of force offered to the world under permission, except that unless we knew they were intended they would have been simply brushed on one side. Tramways do not depend on the rivalry of engineers, and it is to be regretted that one of an order should have been lacking in discretion and thereby have indulged in observations that will not bear discussion, and being described are not worthy of further remark.]

2. *Civil Engineering.*—Mr. Haddon objects to the grooved tram-rail; forgetting that in the miscellaneous locomotion incidental to tramways the groove is a necessity, because the **T** would be absolute, while the groove gives a chance of avoiding danger; and also forgetting that the hard **T** is easily blocked on a tram road, and not on a grooved one. The influence or power of water at high or low pressure belongs to the mechanic of the water works, and is not of any public interest.

3. *Locomotive Superintendent.*—He bids that engines run about eleven hours a-day under one man all through the day. The tubes must be swept in the course of the day, and in hard times relief-men be provided!

Note, in addition:—The men must not be cramped. The public object to close proximity to steam; a huge car is not desirable, as it cannot be used on reasonably sized turn-tables; it must necessarily run half wrong-end first, and therefore requires two men, one with the machinery, and the other to drive; the sides are dangerous, and it requires great power to start.

For these reasons I am of opinion that a detached engine is a *sinâ quâ non.*

Rigid under-frames should be condemned, as also crank axles, owing to the cross bending strains incident on an irregular road; coupling rods, because of the curves; and eccentrics and open axle boxes, by reason of the mud.

Volute springs have not been found to answer, the old **C** spring is far superior in distributing the shock.

Free play to the horizontal boiler, both laterally as well as longitudinally, is imperative, as, if fixed, it is so affected by the curves that the tube plates converge and tight tubes are an impossibility.

The brake should never be applied on the wheels, but on false tyres readily renewable. They should be applied on both sides of the engine, and should not be arranged so as to strain the coupling rods, by either forcing the wheels together or driving them apart, nor should counter-balanced wheels be used. These apply also to the cars.

The joint surfaces should be double used in a locomotive, owing to the constant use of the reversing lever and endless stoppages, which tax the engine severely.

In America the stoppage and starting of a goods train costs a two mile consumption. Half a mile trams are 4 lbs., and stoppages are 600 a day per engine.

Management.—Steam tram differs from horse tram traffic: it pays in Paris 9 per cent., and horse traffic does not pay.

On making the comparison, per mile only, instead of per mile in conjunction with weight carried (receipts), we find the cost in favour of horses. But when we reduce the competitors to the test of work done, the result is greatly in favour of steam.

Horse and Steam Traction.

Classification.	Nature of road.	Working expenses per mile run.	Receipts per mile run.	Receipts per seat, averaging 0.45d. per mile, if full.	A. Working expenses per mile. Work done equal in all three cases.	
			s. d.	d.	d.	
Steam .	Steep	7·43	2 8	0·68	7·43	
Horse line .	Easy	6·40	1 10	0·46	8·49	Average 9·93
Horse line .	Steep	8·56	1 2½	0·30	11·37	

The fares of the car of 48 passengers, when full, represented 3s. per mile, but on certain days the earnings have amounted to 5s. 9d. a mile. The useless number of journeys run by horses, and the value of the consequent extra dead weights may be realised on occasions when the receipts only averaged 1s. 2½d. The cost of steam traction, with two full cars instead of one, is only increased ¾d. per mile for fuel and oil, which brings the cost per mile up to 8·18d. (in France), or less than horse traction on a far easier line with only one car.

In Paris, 10 horses work one car a day, and do about 12 miles; but with so large a car this number of horses would not be enough, if managers did not relieve their horses, by giving an average less than half loads by running double the number of trips necessary.

MANUFACTURE OF GUNPOWDER WITHOUT WATER.

SINCE the general adoption of rifled cannon not a little attention has been given to the improvement of the powder employed for these weapons, the object having been to obtain a powder which would be at once little injurious to the gun, and would have a satisfactory uniform ballistic force. A commission was appointed in Russia in 1871 to study this question. One of its members, Colonel Winer, taking up an idea once suggested by Saint Robert, proposed to manufacture powder without employing water, and by compressing the materials at a temperature a little higher than that of the fusion of sulphur.

The advantages of powder thus prepared are as follows :—(1) Its hygrometric property is diminished, and so it is less affected by remaining long in damp places. (2) The manufacture is less expensive, because drying-rooms are dispensed with, and the mixture of the constituents takes place in mixing drums instead of mills. (3) The danger in manufacture is diminished. As the drying operation takes a long time, large quantities of the material are necessarily accumulated in the drying-rooms, whereas, when the powder is prepared directly in the dry state, only small quantities are treated at one time.

Winer was charged to make experiments in this direction in the works at Okhta, and he made the necessary arrangements for the purpose. The latter consisted of a hydraulic press, to which were adapted two hollow plates of copper connected by two pipes of the same metal for passage of steam. The lower plate was screwed on the plate of the press which was fixed on the piston, and communicated, through a caoutchouc tube, with the steam pipe. The upper plate was fixed, and put in communication with the steam pipe by means of an iron pipe. The pulverulent and dry mixture, prepared in the drum, was spread uniformly on the lower copper plate, then the piston was set in motion, and pressure was produced for ten minutes. The disc of powder thus obtained was a perfectly homogeneous mass. The temperature of the steam was about 120 deg. C. With a pressure of 130 atmospheres, measured in the manometer, cakes were got with a density of 1·80 to 1·9; with 30 atmospheres, it was 1·66 to 1·7. These pressures correspond respectively to 114k. and 25·4k. per square centimetre. The cake was reduced to grains by means of crushing cylinders. By means of a sieve the grains were isolated from the rest of the powder; and, lastly, they were discharged into bags.

The comparative experiments made in 1871 with the compressed powder and ordinary powder were not considered satisfactory, and merely gave an impulse to fresh experiments. Only in 1874, after having experimented with a long series of compressed powders of different grain and density, did Winer find one which answered the requirements. This powder had a density of 1·6, a grain of 6 to 8m., and gave with a charge of 2·250k. in a long range 4-piece, an initial velocity of 471·5m. in the projectile. The tension of the gas was 1366 atmospheres.

The new powder was next compared with ordinary powder with reference to hygrometricity. In a vessel filled to about a fourth of its height with water were arranged 0·10m. above the surface of the water, two sieves containing the one 24·6k of ordinary Okhta large grain powder (density of 1.75, grains 6·3mm.), and the other the same weight of Winer powder (density, 1·6; grains, 8·9mm. to 10·2mm.) The vessel was closed with a lid covered with wax cloth, and left in the open air from August, 1875, to 25th October following. On re-opening it the grains of the ordinary powder were found covered with moisture, black, and so soft that, under pressure with the fingers, they were reduced to a viscous mass; the grains of the Winer powder were also slightly coated with moisture, but still quite firm, and they could only be crushed with pretty strong pressure. The former powder contained 6·75 per cent. of moisture, the latter 2·1 per cent. The firing of the long-range 4-piece with these powders, first dry, then moist, gave the following result :—

Species of powder.	State of Powder.	Charge.	Initial velocity.	Maximum tension of gas.
		k.	m.	atm.
Winer powder	Dry	2·050	438	919
	Moist	2·050	388	778
Ordinary large grain Okhta powder	Dry	2·350	456·3	1245
	Moist	2·350	323·1	641

The Winer powder lost by its lying in the vessel 11·4 per cent. of initial velocity, and the ordinary Okhta powder 29·2 per cent.

The two samples of powder were then subjected to slow drying, at the temperature of 10 deg., from 25th October, 1875, to 5th January, 1876. At the end of this operation the ordinary powder was porous, and rugous in aspect, with efflorescences of saltpetre. The Winer powder, on the other hand, presented nothing abnormal. In firing, these two powders so dried gave the following result :—

	Charge.	Velocity.	Tension.
	k.	m.	atm.
Winer powder	2·050	434·6	1212
Ordinary powder	1·840	421·5	1166
" "	2·050	443·8	1390
" "	2·250	473·3	1620
" "	2·350	476·6	1660

Thus the Winer powder gave nearly the same velocity as before the humidity test, whilst the ballistic properties of the ordinary powder were sensibly modified.

Colonel Winer further submitted to the humidity test two other samples (or ordinary powder with grains 6·3mm. to 10mm., and 1·75 density; Winer powder with grains 5mm. to 6·3mm., and 1·6 density) which remained two weeks and a half enclosed in the vessel. The results of firing were these :—

Species of powder.	State of Powder.	Charge.	Velocity.	Tension.
		k.	m.	atm.
Winer powder	Dry	1·95	457·5	1704
	Moist	1·95	457·8	2200
Ordinary Okhta powder	Dry	2·35	456·3	1245
	Moist	2·35	417·0	2060

Thus with the moist Winer powder there was no loss of velocity, while with ordinary powder the velocity was diminished 8·6 per cent. The experiments were conclusive as regards the relative hygrometricity of the two species of powder.

It is easy to account for this difference of property with ordinary manufacture. The water used in moistening disappears in the drying process and leaves in the grain small channels or pores, by which the moisture enters afterwards. Such channels do not exist in the powder manufactured without water.

The new powder is now being experimented with in Russia on a large scale for field guns. Colonel Winer has received an order for 82,000k. of it. But hitherto it has not been found possible to prepare a powder of this kind, suitable for 8 in., 9 in., or 11 in. cannon, and capable of replacing prismatic powder. The above experiments are described in a recent number of the *Journal d' Artillerie Russe.*

IMPROVEMENTS IN METALLURGY.

ON both sides of the Atlantic this subject is almost superior to any other, and the time is past which permitted book-makers to beg and to borrow in order to dress up a quasi-instruction. It is of no use whatever to re-describe the methods in vogue for the last fifty years unless they can be so criticised as to suggest improvements, especially in the matter of working the ores. Metallurgy is at the present time one of the most actively progressive of the sciences, although its most able devotees make no claim to such distinction. The miner, the chemist, the manufacturer, the trader, and the public confess by their deeds the confidence all have in the future of metallurgy. We have of late frequently reverted to it because of this universal tendency, and now reproduce sentiments expressed "over the water" that are worthy of regard, because they are practical in their aim, and if used at all must yield a profitable result.

Are the stamps and pans now used sufficiently perfect to satisfy the ends desired in their formation? Those in use are simple enough, and the dullest workman or superintendent has enough qualifications to meet the demand, and this simplicity has given them position, especially after the success of their adoption in rich and profitable mines. But it is a question whether these machines having failed to pulverize the ore to the required fineness for a profitable division of the precious metals —gold and silver—have not also failed in the special work it had in hand. If some coarse gold ores can be made to yield almost their assay value when reduced fine enough to pass a 10 mesh sieve, *i.e.* 100 holes to the square inch, surely it is time to review the former calculations!

The successful mines have given preference to the 40 mesh sieve or screen for stamps = 1,600 holes per square inch, up to

the last five years; but now the 60 mesh is preferred, and the change of idea indicates progressive knowledge. From the stamps the precious ore is taken to the amalgamator pan, where it is further pulverized on being ground into the quicksilver. This further pulverizing is slight, but it is apparent, and is effected at a disproportionate expense. The cost of the wear and tear on the pans is about three times that upon the stamps; for in grinding and rubbing the hard quartz, or other stone, has the advantage of iron. "Tailings" are still sand, and must not be treated as powder, and they often contain smaller particles of precious metals which further pulverization with quicksilver would have brought to view.

After many experiments and the testimony of practical men, it is clear that a much finer pulverization would add 25 per cent. to the product of even the successful mines, and would make profitable many that are now worked at a loss. But to effect this new machinery is required. The amalgamator and the pulverizer will have to be improved, and the principle of separating absolutely the metal from its encrustation must be recognised: most likely the two will work together. Perfect pulverization may do all the work and thus save the application of a second process, such as rubbing or grinding, which destroys as much as it produces. The metal should go from the pulverizer to the quicksilver, and we want better machines before that result can be attained.

SCIENTIFIC JUGGLERY.

PROFESSIONAL conjurors will have to adapt their art to the scientific tendencies of the age if they would maintain their high position. Making omelettes in hats, and causing cards to disappear and re-appear, are types of a large family of useless devices, and we don't know that this last new phase from New York city is much better: it however affords a new way of mystifying, amusing, and perhaps instructing the audience.

The *Scientific American* tells us that a Mr. Heller has a neat way of bringing the electric current to his aid. After borrowing a few watches he places them on a plate, suspended by a piece of string, from a little bar between two cords, from the ceiling. A sudden flash comes from the bar, the string is burned, and plate and watches fall with a crash. The broken plate and ruined watches are restored by shooting them out of a gun, against a framed black square, which is suspended by cords from the ceiling: here, again, the electric current actuates mechanism, which causes the lightning-like disappearance of an interposing screen. The current again works the hammer of a glass-bell, apparently suspended by a mere thread, but which accurately counts the number of spots on chosen cards.

In electro-music this performer seems to be an expert. A dozen or more drums are heaped on a kind of barrow in the middle of the platform. He sits to his piano at a distance and plays a lively air, to which the mysterious drums first beat time and then play a deafening accompaniment. The effect is produced by concealed hammers that are operated upon by electro-magnets, placed at the bottom of the puzzle. He has also an orchestra, but that is a much more elaborate affair. There is a good-sized barrel organ provided with a supplemental keyboard, and surmounted with a bewildering mass of brass tubes and apparatus. The performer plays an air, and he is suddenly accompanied by a chime of large bells at the further end of the hall, and then by small bells near at hand: then another organ near the ceiling peals forth notes like a flute, to which a chorus of sleigh bells in another part of the hall respond and unite. The general result is an imitation of a storm, and a huge iron plate in another quarter rattles itself, while from a box near the ceiling there issues the sound of falling rain. Finally, two sharp explosions are heard proceeding from miniature guns near the roof, the lights are turned down, and upon the organ there appears revolving Geissler tubes flashing out green and blue light in the weirdest manner, just as the curtain falls hiding the performer and his apparatus from view. Nor is this all. There is a number of ingenious illusions, some of which depend on automatic and many on electric action. For instance, from a simple trapeze suspended from a bar over the platform he seats a doll dressed as a gymnast. The trapeze is set swinging, and then the doll goes through a series of performances of such a variety that it is impossible to imagine how it is done. This lasts ten or fifteen minutes. The hands alone touch the trapeze bar, and the mechanism in the body is necessarily governed through the ropes and cross piece: but how at the end the figure lets go with its hands, throws a summersault, and catches on its toes, swinging again in that position, is not easy of explanation. Another automaton is a peacock that cries, moves its head, eats, and spreads its tail when ordered to do so. Another is a doll which comes from the inside of a box, sets itself on the edge, performs a lot of ridiculous antics, and ends by smoking a pipe, which it puffs the smoke of in the most natural manner.

Perhaps the clever author will by-and-bye add to the interest of his wonderful performance by a twenty minutes' explanation of how it is done. It would not injure his revenue in the least.

SANDAL-WOOD.

MUCH attention has been given of late to the subject of utilizing the woods that are nature's prolific gift to man, and as has been often said of late in this Journal, there is danger of destroying what we should do our best to preserve. The odour of the sandal-wood is familiar to all who have the "five senses," and a welcome perfume it is held to be. Some have thought it might be utilized for furniture to a greater extent than it is, but one is inclined to question whether the finest odour in the universe would not become annoying if it met you at every turn in the house. Sandal-wood has not yet incurred the danger, because it has not run the risk. Every one is familiar with sandal-wood fans that are imported in large numbers from China every year, and are sold retail for about two shillings, but the Chinese are not likely to spare great blocks unless "for a consideration." The value is great, and the Chinese having a great respect for his religion will not forego one of the choicest materials for its observation unless he gets a high profit. Then, we fear, his devotion must give precedence to his interest. Sandal-wood is when burnt the purest incense the Eastern can offer at the shrine of his gods.

Nevertheless, the people who will not part with tree-bulks can sell the shavings, and make them as thick as they may be inclined to do in regard to living in this world with tolerable comfort. In Bombay and in England there is a considerable demand for fancy boxes carved in the Eastern style—ivory-fashion—and the wood for such purposes finds its way to Surat. There it undergoes mechanical conversion, and the boxes find their way all over the world to the confusion of the cedar trade, and the obliteration of the Canadian-pine cedar substitute.

It is a carvable wood, and might be so employed in England. Every one knows, as above stated, that the Easterns treat it as they would ivory, but whoever heard of an English carver exercising his vocation on a block of sandal-wood? This is an omission. The best sandal-wood grows at Mysore, and from thence there would be attainable large supplies if the trade were to take the direction; or which is of vastly more importance, public taste gave a demand. From Mysore, as matters now go, the sandal-wood is sent to China and Arabia, and only the odds-and-ends go up the coast. The wood is clearly less profitable to the sellers, and of little use to the artizan. Traders can create a demand by judicious introduction of new material, and the sandal-wood trade is worth attending to.

There are about five general classes into which the qualtities of this substance may be divided. Of these the three chief go to China. The hollow billets and small broken pieces of these go to Arabia, where they are sold for burning in elegant rooms as perfume of the purest, or are dried and pulverized to be mixed with other substances as incense. The Parsees buy the inferior descriptions that arrive at Surat, and burn them in their fire-temples; and the relatives of deceased Hindoos who are able to afford the purchase, acquire them for the funeral rites of their friends. This last use causes a considerable dispersion of the material, which is sent up by carts to various places in the presidency. The sandal-wood is used by all Hindoos for caste-marks; for that purpose it is rubbed down and worked into a paste, and that paste is also employed as an external application to persons afflicted with headaches and some skin diseases. One of the conservators of the Mysore Forest relates that when travelling in the neighbourhood of Bombay he came across two funeral processions, both of which had billets of sandal wood designed for adding to the funeral pile where the bodies were to be burned; and the priests in the Parsee country will gladly obtain and preserve a small log or two to add to the attractions of their temples and their office.

At present the sandal wood is, from these causes, almost entirely one of retail in the neighbourhood of Mysore; but the

surrounding villages contrive to use about fifty or sixty tons a year.

Sandal is grown at Surat, but it seldom attains the size of the Mysore tree; the wood is small, knotty, and of much less fragrance. The Mysore product is known technically and commercially by the name of "Malabar sandal," and in the very neighbourhood few know that it does not come from Malabar, although it is really the produce of Mysore. Australia is now doing a good trade in this line. In 1847 she sent out from New Caledonia, the New Hebrides, and the neighbouring islands, a thousand tons a year from the port of Sydney to China, where it was burned with other incense in the temples. Eight or ten vessels are constantly engaged in the trade, and the wood realized as much as £30 a ton. It is not equal to the other; but it does to offer to the gods where the wood of Mysore commands much more than double the money.

Practical Literature.

RUSKIN ON THE TUSCAN MASTERS:—THE LAWS OF FIRSOLE.

THE dear good man whose history will have to be written a many times is now in a state of physical weakness that all his contemporaries deplore. The *Practical Magazine* has recognised in him what all must acknowledge, a marvellous influence upon the age in which his lot is cast. His last book therefore comes with a claim on our affection as well as upon our respect, and it is fine to listen to his advice to a young Italian painter who had sought his instruction.

I. "The greatest art represents every thing with absolute sincerity as far as it is able: but it chooses the best things to represent and places them in the best position. It is by the process of time that the improvement of your own nature and character can be effected, and then you will be qualified to judge of what is best. But of what is true you can learn at once, if you desire so to do.

II. "Make all your drawing studies of the real size. A man is to be drawn the size of a man, and a cherry the size of a cherry. You say 'I cannot draw an elephant of the size of an elephant.' There is no occasion for you to draw an elephant. 'But nobody can draw Mont Blanc its real size.' Well, nobody can draw Mont Blanc at all, but only a distant view of Mont Blanc. You may draw also a distant view of a man, or an elephant, but you must take care it is seen to be a distant view, and not likely to be mistaken for the drawing of a mouse or a pigmy near.

"But, you say, 'there is much good miniature painting.' Yes, and also fine cameo-cutting: but I will teach you to be a painter, and not a locket-decorator or medallist.

III. "Acquire by your first efforts the power of drawing a perfectly accurate outline of any object of its real size, *as it appears at a distance* of not less than twelve feet from the eye. All the best art takes no less distance, because you cannot realize the size and nature if you go nearer.

IV. "You cannot learn to draw a thing by learning its nature and structure. Surgeons must study anatomy, and apothecaries botany; and geology is a necessity to miners. But neither of the three can help you to draw a flower, a mountain, or a man. You must look at these as they are if you wish to learn to draw them: they must not be cut to pieces. You can't paint a peach by finding out that there is a stone inside, nor a face by learning that it is the front of a skull.

V. "When you can make accurate outlines learn to colour them truly: for if you can colour accurately, and lay your colour on as tenderly as does nature, that is to be a painter; just as, if you struck a note truly and delivered it clearly, you would be a singer. In the one case you could choose what you would paint, in the other what you would sing.

VI. "Of colours: a pea is green, a cherry red, and a blackberry black, all round: but every light is a shade when compared with higher lights until we come to the sun: and every shade is a light compared with deeper shades until we reach the night. Therefore when you have made your outline do not ask whether it is in light or in shade, but only of what colour, and of what depth in that colour.

"Shadow is said to be gray, but Corregio when placing his shadows with one colour used red chalk.

"Because distant mountains are blue that is called a retiring colour: but sunset behind them is further off and must be painted with red or yellow

"If your picture is beautiful the observer will not care whether there be sunshine or not in the outer world, although fine weather is pleasant. When you meet your friend in the sunshine you take him into the shade for converse, and if you wish to speak to your friend by the picture you must do the same.

"It is good to be economical in all things, and especially in candles. When the time compels you to light them, go to bed: do not draw by them, for that is the worst waste of time. And never omit to see the sunset and the dawn. For a painter this can be advised in addition, 'never, if you can help it, see anything but dreams between.'"

Ruskin is very paradoxical, and a veil must be drawn. We have given a fair translation of his instructions and abridged them to render them useful. At the end of this we quote, "The king has presented an Etruscan vase of utmost beauty to the Neapolitan Museum. 'What a pity I cannot draw it!' In the meantime the housemaid has broken a kitchen tea-cup; let me see if you can draw one of the pieces."

And one more illustration of his paradoxical method that is really good in some cases and as really worthless in others, but characteristic of the greatness and beneficence of his nature.

"When you would do your best stop instantly if you find a difficulty. Your drawing will be without doubt as good as you can make it, but it would be no better by waiting until to-morrow. When you would do *better* than your best put your full strength out on the very instant you meet with a difficulty. In so doing it is possible that the drawing of to-day will be spoiled, but to-morrow's best will be no better." Again, said the proud young scholar, "I can do what I like with my colours." "Ah," said the master, "so could I at your age, but now I must do what others bid me."

These words contain little more than the ordinary conclusions of an observant London man, whose tastes, tending toward art, are under the control of a set of principles that are its superior when compared with others of distinguished renown: but nevertheless they carry evidence of the human sympathy with life which we know carried through a private life of wondrous renown, which we hope will long be continued.

Chemistry applied to the Arts, Manufactures, etc.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF SOCIETIES, ETC.

Waste Material of Parchments.—C. O. Cech in *Dingler's Journal* states that a manufacturing firm in Berlin is now collecting and utilizing the waste material obtained in the manufacture of parchment, for the purpose of obtaining therefrom oxalic acid. This waste has hitherto been burnt.

Fining of Wines.—Wines are filtered by several methods through paper or sand, and with and without pressure. M. A. von BABO'S method of purifying is by the use of isinglass, 3½ decigrammes to about 860 litres of wine, whipping it into a froth, and allowing it to settle. Milk, in the proportion of a litre of fresh milk, or 1½ litre of blood, or 12 fresh eggs to 150 litres of wine may also be used. Gelatine is also advantageous.

Another Telephone.—At a recent meeting of the Royal Society of Edinburgh, Sir W. Thomson gave some explanation of the telephonograph. All previous attempts to record sound were, he said, founded on the motion of a style or marker at a true parallel to the paper. Mr. Eddison's ingenious invention of the electric pen was different. It consisted of a fine point, which, by an excessively rapid vibration perpendicular to the paper, caused by a small electric machine connected with two thin wires to the point, left a trace of any person's handwriting in a row of very fine holes, from which the handwriting could be printed. Mr. Eddison, from this invention, elaborated the phonograph. By the greater or less pressure produced through the action of the alternate condensation and expansion of the air caused by the mechanism of the voice, the diaphragm operated upon the point and recorded the sounds. It was the most interesting mechanical and scientific invention they had heard of in this century. There could be no limit to its application. A man could speak a letter through the phonograph—it would be recorded on tinfoil, sent in an envelope

through the post, and his friend, by applying the point of the phonograph to the tinfoil, could reproduce the words and tones uttered.

Magic Lantern; Leakage in Gas-Bags.—When small leaks occur in bags used for gas to supply a magic lantern, they can be closed with thick boiled glue, mixed with glycerine in the proportion of one part of glycerine to four of glue, applied warm to the bag while filled with air. If too much glycerine is added, the cement will be sticky, which can be overcome by strewing powdered soapstone over it; if too little glycerine is added it is too hard.

Glass-Blowing Monopoly.—Good strong blown glass tumblers are being delivered into English ports from America for 8d. per dozen, and good hexagonal and octagonal cut Dutch tumblers for 4s. 8d. per dozen. The above fact relating to importation from the United States, from whence but recently nothing of the kind was exported, is illustrative of the keen competition in manufactures generally, and in particular shows the necessity for the abolition of the English glass blowers' practice of working but four days per week, a practice maintained by the glass blowers' guild, and one which prevents the continuous operation of the costly furnaces and plant in a glass works. A smaller profit on most English goods will have to be accepted in the near future.

Combination of Jute with other Fibres.—We have frequently shown the peculiar difficulty in treating jute arising from the difficulty of bleaching and colouring. Every one ought to know that half the silk goods are crossed with jute, and half the fancy haberdashery made of cotton or linen is also crossed with jute to make them silk-like, but in bleaching the two materials differed: they took opposite grounds when undergoing that process, the one becoming white and the other brown, or otherwise. The ingenuity that assumes to conquer difficulties has led adventurers to treat these fabrics in combination after weaving by printing upon the result certain colours well distributed and shaded, whereby there is obtained great novelty and brilliancy. The idea is a good one. Will the dyed jute bear the test of time; and will the combination continue to be harmonious and bright? Great advantages are offered, but will they ever be likely of attainment?

Emery Fabrics.—Emery paper is considerably employed for cleaning and polishing metals, but all the kinds in use hitherto have the great disadvantage of not retaining an equal efficiency. The fresh parts bite too much, and the paper itself soon gets worn through in places. Emery on linen has been tried, but without success. There is a new board in which emery enters as a constituent part. Fine and uniform cardboard pulp must be procured, and from one-third to one-half its weight of emery powder thoroughly mixed with it, so that the emery may be equally distributed. The mass is then poured out in cakes of from 1 in. to 10 in. in thickness. They must not be pressed hard, however, but allowed to retain a medium pliability. This paper will adapt itself to the forms of the articles, and will serve until completely worn out. [This is all very well on paper; but any one who knows the manufacture cannot fail to see that the idea is one favourable to adulteration, which is the curse of all modern manufacture. "In your board pray how much dirt do you allow?" The cabinet-maker asks that and he has some right to speak. We have quite trouble enough with what is called emery cloth: but the old emery paper never caused any one to complain.]

Statistics of French Steam Power.—The total power of all the steam engines existing in France according to recent official statistics, is 1,500,000 horse-power, representing the actual labour of 4,500,000 horses, or 31,590,000 men. This last aggregate is equal to ten times the present industrial population, which amounts to 8,400,000 souls, but from which must be subtracted old people, women, and children, leaving a remainder of 3,200,000 working men. *La Nature* compares the above data with the similar statistics of 1788, before steam engines were introduced in France, and illustrates the revolution which steam and improved machinery have produced. Ninety years ago, in every £40,000,000 worth of French products, 60 per cent. of the value represented labour and 40 per cent. raw material. To-day this ratio is exactly reversed, although labour has increased 40 per cent. At the present time the total industrial productions of France aggregate a value of about £480,000,000. Of this £280,000,000 represent raw material, and the remainder labour. If the same proportion as existed in 1788 applied now, taking into account the increase in labour noted above, no less than eleven-twelfths of the above amount, or £440,000,000, would be the cost of handiwork. Roughly, then, steam engines and improved tools have produced an economy of £240,000,000; but, more than this, if they were suddenly swept out of existence and forgotten, there are not enough men and animals in the country to supply an equivalent amount of power, and even if there were there would be no way of procuring the necessary food for their support.

Cochineal-red for Woollen Goods.—A new method of obtaining this costly substance is thus formulated by A. Keelmeyer: Fourteen kilos gum are mixed with 15 litres of water, 17·5 kilos, of cochineal lake, and 2·25 kilos of fustic acid are added: the whole is warmed at 600 until dissolved; then 1 kilo of oxalic acid and 1·75 kilos of acid sodium oxalate are added; and after solution, and when the whole is become cold, 2·25 kilos of crystallized sodium acetate are thrown in. The goods, after dyeing, are dried at a gentle warmth for one or two days, then steamed under a slight pressure, well dried, washed, and again dried.

Dyeing with Aloes.—The colouring matter from aloes may be obtained by digesting 10 kilos. of the resin in 60 kilos. of nitric acid. After a strong disengagement of gas, the golden-yellow liquid is evaporated, first over a sand-bath, and then over a water-bath, and finally water is added. This precipitates the colouring matter, which however requires purification with water before it can be dried. In this manner about 66½ per cent. of pure colouring matter is obtained, which is completely soluble in water, alcohol, or ether; with this substance and its combinations, wool and silk have been most successfully dyed, the colouring matter being used in a variety of ways, and the colours obtained being most varied and well fixed.—V. PRESTON in *Chem. Centr.*

Railway Lamps.—We understand that the Great Northern Railway Company have, after twelve months' trial, decided to adopt Messrs. Davies and Thomas's railway lamp, as made by Messrs. Ridsdale of the Minories. The lamp is simple in construction, is supplied with ordinary lamp oils other than mineral oils, and gives a brilliant and steady light, the brightness of which is much aided by the use of a glass chimney. The latter is an addition which might appear as an objection, but the percentage of breakage is stated to be but 0.02 per cent. of the whole. The wretchedly imperfect lights provided in many carriages make it desirable that improvements of this kind should be carefully examined by those who have to consider the welfare of railway passengers, and their adoption, moreover, as old types of lamps wear out, costs little or nothing more than renewals of the common lamp, which gives a light sometimes scarcely preferable to darkness. During the recent trials with an 8 in. roof lamp giving a ten-candle flame, and supplied with oil at 3s. per gallon, the light is said to have lasted without trimming or deterioration for thirteen and a-half hours, consuming 14½ oz. of oil, equivalent to a cost of about ¼d. per hour. These trials took place in the carriages running from London to Glasgow, and the light was found to be quite steady in a heavy gale.

A New Method of Rendering Glass Opaque.—The various methods now in use for rendering glass opaque, are, first, painting or covering one of the faces with any opaque white substance, such as alabaster, barytes, &c., mixed with oil. Second, causing the surface to be attacked by hydrofluoric acid. Third, covering the surface with ground glass in powder, and submitting the whole to vitrification at temperatures low enough to cause adherence of the powder without producing deformation of the sheet. Fourth, grinding the surface with emery. Fifth, abrading it by the sand blast; and sixth, depositing thereon a salt in crystalline form. A new process has recently been devised by M. Aubriot, by means of which he produces so-called muslin glass, of a variety of colours. He proceeds as follows:—After carefully cleaning the surface a layer of vitrifiable colour is laid over it. The vehicle is simply gum water, and care is exercised that the pigment is evenly applied. The glass is then submitted to a mild heat until the water has evaporated, when a stencil of the desired pattern is laid over the surface, and a stiff brush is used to remove the loose pigment from the parts which are to be transparent. The glass is next enclosed in a frame, and above it is extended a piece of tulle, or, if desired, embroidered lace, the embroidery in the latter case being so disposed as to harmonise with the ground pattern previously made. The whole is then hermetically closed in a box, which contains in its lower portion a reservoir in which is a certain quantity of dry colour in the form of impalpable powder. This, by an air blast,

is blown evenly upon the glass, and adheres to the latter wherever the surface is not protected by the threads of the lace. In this way the pattern of the latter is defined. In order to fix the powder, the sheets of glass are placed in a steam chamber, where the steam moistens the gum and causes the powder to adhere. The colour is then burned in a special furnace. By using different colours, it is said that very beautiful designs can be produced in this way, opaque or transparent, according as the pigments themselves are the one or the other. Remarkable effects also are obtained by the superposition of the tints.—*Furniture Gazette.*

Improving the Tone of Metal Alloys.—Many alloys of tin and other soft metals hardened by addition of antimony, copper, &c., do not give a clear tone on being struck, but a lead-like dull one. It has been found by M. Lilliman that the power of sounding clearly may be imparted to them, by immersing them for a half to one minute in a paraffine or oil bath, heated to a temperature 5 deg. to 5·5 deg. below the boiling-point, then taking out and allowing to cool. This does not produce any diminution of density, but a considerable increase of the hardness and rigidity.

How to make a cheap Telephone.—In his lecture Professor Barritt gave a recipe having this object, viz. :—Take a wooden tooth-powder box, and make a hole of about the size of half-a-crown in the lid and in the bottom ; then take a disc of tinned iron, say from a preserved-meat tin, and place it on the outside of the bottom of the box, and fix the cover on the other side thereof. Take a small bar magnet, having on one end a small cotton or silk reel, around which reel wind some iron wire, leaving the ends loose, and fix one end of the magnet as near as possible without touching, to the disc, and one part of the telephone is complete. Adopt the same method to the other end. The two are connected by wire, and conversation at a hundred yards is easy.

Mineral Wool.—A few years ago a process of converting the slag from the iron furnaces into a filamentous substance resembling fine-spun glass or wool was invented in Germany, and latterly the mineral cotton or slag wool as it is called, has been offered as a suitable non-conducting material for covering steam pipes and boilers, and many improvements have been and are effected. This kind of slag is chiefly a silicate of lime, magnesia, and alumina, and an excess of either component changes the character and appearance of the product : a neutral slag yields the finest fibres and the whitest wool. The manufacture is carried on as nearly as possible to the iron furnace, the liquid slag is run into box waggons, and wheeled to the wool chamber. The molten slag is there allowed to trickle in small streams directly in front of high-pressure steam jets, which first blows it into globules, and then into fine threads, which are deposited on the floors of the upper part of the chamber. It is an ingenious idea that will by and bye become a very useful one for the purpose of covering boilers, cylinders, &c., as its temperature can only change by fusing heat.

Sea and Fresh Water Changes.—Many of the harrowing details of shipwrecked men "surrounded by water everywhere but not one drop to drink," attribute delirium and suicide to the drinking of salt water under the goadings of insufferable thirst. However this may be when draughts of sea-water are suddenly and for the first time drunk, it would seem that gradually the animal system of mammalian creatures, as well as those of vertebrates lower down in the scale, such as fishes, may be naturalised in the course of long periods to at least encounter the opposite change, viz., from sea-water to fresh, as in Lake Baikal in Central Asia, which was probably once an inland sea afterwards cut off from communication with the ocean by elevation of the bed and margins of the lake. Palæontological and other evidence proves that like other portions of the great chain of inland seas extending from the Bosphorus far into the heart of Asia it was as salt as the ocean, or perhaps still salter, as is the case with many smaller inland lakes besides those of Palestine. Its waters are, however, now fresh, and amongst its inhabitants seals are found in abundance not differing from those now existing in the sea-waters of temperate latitudes, and fish, which cannot be distinguished from the well-known migratory herring coming annually to our own shores. In the course of ages the Baikal waters, originally salt, have, by influx and efflux of pluvial waters, become gradually more and more fresh, and thus through many generations those salt water animals, and probably others not yet discovered, have become acclimatised to the change from sea to fresh water, and with but little change in size, form, organisation, and functions. We have here then one side of the metamorphosis, but Lyell, somewhere, which from memory we cannot recall, mentions that by the breaking through during heavy storms of a large sandy bar separating a large freshwater lake in Scotland from the sea, the waters of the latter were permitted to flow into and mix with the previously fresh water, which after a not very long period became as salt as that of the neighbouring sea, with the extinction of some species previously inhabiting the lake, but with the survival of others which bore the change of elements with impunity. It is far more remarkable, however, where the change affects man himself, and the facts recorded as well as the examination of such changes in the organisations, functions, and secretions of the human being, as we cannot but expect must arise from the human stomach receiving not the mild and thirst-allaying drink of fresh water, but receiving daily several grammes in weight of the saline constituents of the ocean, seem worthy of careful examination by the naturalist.

Imitation of "English Red" and "French Ochre."—MM. Steinau of Brunswick, Germany, has lately patented a new method of preparing these colouring matters, or at least an imitation of them. It consists in producing a pure iron oxide simply with water and the oxygen of the air. Wrought-iron turnings are placed on a sieve in a vessel, in which water is forced up and down by a piston, so that the turnings are alternately in water and in air—which latter, entering the vacuum with force, has a strong oxidizing action. After the piston has worked some twelve hours, the hydrated oxide is allowed to settle at the bottom, then removed, filtered, and dried.

The Effect of Lead on Paraffine.—In the course of a lengthened series of experimental observations of various paraffine oils, detailed in a paper by Dr. Macadam, read lately before the North British Branch of the Pharmaceutical Society, attention was directed to a certain oil which burned somewhat imperfectly in different lamps. It was feared that this oil was contaminated largely with lead compounds, which choked up the wick and ultimately diminished its capillary attraction so much that the light was extinguished. In a single night the wick of the lamp had to be changed several times, and the wicks when charred left a fine net-work of lead. The oil had been stored in a tank lined with lead, and dissolved so much of the lead that its value as a luminant was destroyed. The action of the oil on tin, copper and iron was so slight that its light was not much diminished. Zinc, however, was much affected, and the oil was consequently rendered nearly as useless for illuminating purposes by it as by lead. Dr. Macadam suggests that, while vessels may be safely constructed or lined with tin, copper or iron, it would be preferable to use cisterns lined with enamel.

Telephone Wire Insulation.—*Nature* reports experiments made by the Hon. Rollo Russell which goes to prove that there is no need to insulate the wires connecting a pair of telephones—at least, when used for short distances. No. 18 uncovered copper wire was laid along grass and trees 418 yards, the two lines being kept well apart. Articulation and a small musical box were very well heard. The same wire buried for 3 yards in wet clay, the lines being about 5 ft. apart, and the telephones 20 yards apart, gave good results ; and it appears that the bare wires may be taken under roads, &c., without diminution of the audible effect. With the same wire, taken across a pond, the lines being submerged in water about 40 yards, and lying on the grass the rest of the distance about 28 yards—the wires were about a yard apart in the water—conversation in low tones was distinctly heard, when not overpowered by the noise of a strong wind blowing at the time. Probably No. 18 copper wire, uninsulated, might be laid across rivers and straits, and used for telephonic purposes without appreciable loss of sound, as Mr. Russell, not in any of the above cases, noticed a feebler effect than with insulated wires.

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